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Publication Office.—41, Queen's Gate, London, S.W.7.

(K2931) Wt 14/10 36 1,000 7/26 H & SF Gp 52

CONTENTS.

ORIGINAL ARTICLES.

	PAGE
ADLER, S. & THEODOR, O. On the <i>minutus</i> Group of the Genus <i>Phlebotomus</i> in Palestine ...	399
AUSTEN, E. E. A Contribution to Knowledge of the Blood-sucking Diptera of the Dardenelles	1
Concerning the Nomenclature and Synonymy of certain Oriental and East African Blood-sucking Muscids (Diptera)	307
BALLARD, E. & HOLDAWAY, F. G. The Life-history of <i>Tectocoris lincola</i> , F., and its Connection with Internal Boll Rots in Queensland	329
BEZZI, M. Some Tachinidae (Dipt.) of Economic Importance from the Federated Malay States	113
BODKIN, G. E. The Fumigation of Citrus Trees in Palestine	143
BOX, H. E. Sugar-cane Moth Borers (<i>Diatraea</i> spp.) in British Guiana	249
BOYD, M. F. A Note on the Rearing of Anopheline Larvae	308
BUXTON, P. A. & HOPKINS, G. H. E. Race Suicide in <i>Stegomyia</i>	151
CHAMBERLIN, J. C. Supplement to a Monograph of the Lacciferidae (Tachardiinae) or Lac Insects (Homopt., Coccidae)	31
CHINA, W. E. A New Species of <i>Triphleps</i> (Heteroptera, Anthocoridae) preying on eggs of <i>Heliothis obsoleta</i> , H. S., in Queensland	361
CORBETT, G. H. Contribution towards our Knowledge of the Aleyrodidae of Ceylon ...	267
COTTERELL, G. S. The Hispid Leaf-miner (<i>Coelaenomenodera clacidis</i> , Maul.) of Oil Palms (<i>Elaeis guineensis</i> , Jacq.) in the Gold Coast	77
COWLAND, J. W. Notes on the Sweet Potato Pyralid Moth, <i>Megastes grandalis</i> , Guen	369
DUTT, G. R. The Giant Mealy Bug and its Control	155
FEDOROV, S. M. <i>Theresia ampelophaga</i> , Bayle, in Crimean Vineyards	393
FERGUSON, E. W. Additional Notes on the Nomenclature of Australian Tabanidae ...	293
FERRIS, G. F. The Generic Types of the Diaspidae (Hemiptera).—Introduction ...	163
FLETCHER, T. B. Migration as a Factor in Pest-outbreaks	177
GAHAN, A. B. & WATERSTON, J. Notes on Encyrtidae (Hym.-Chalcidoidea) bred from Psyllids, with Description of a New Species	373
GIRAULT, A. A. A new Parasite of Bug Eggs (Proctotrypidae)... ..	183
HAGA, J. A New <i>Uranotaenia</i> (Culicidae, Diptera) from Alor, Lesser Sunda Islands	43

	PAGE
HARGREAVES, H.	
Notes on the Coffee-berry Borer (<i>Stephanoderes hampei</i> , Ferr.) in Uganda	347
HOUGH, W. S.	
The Internal Anatomy of the Clover Root Mealy-bug, <i>Trionymus trifolii</i> , Forbes (Homoptera, Coccidae)	25
KARNY, H. H.	
On some Tropical Thysanoptera	125
On some Tropical Copeognatha, especially from the Fiji Islands ...	285
KEMNER, N. A.	
Some Termites from Ceylon	379
KING, H. H.	
A Note on the Bionomics of <i>Tabanus fasciatus niloticus</i> , Aust. ...	359
KING, H. H. & JOHNSTON, H. B.	
A Simple Form of Distributor for Insecticide Dusts	175
KLIGLER, I. J. & THEODOR, O.	
Effect of Salt Concentration and Reaction on the Development of <i>Anopheles</i> Larvae	45
LAING, F.	
Descriptions of some New Genera and Species of Coccidae ...	51
LEAN, O. B.	
Observations on the Life-history of <i>Helopeltis</i> on Cotton in Southern Nigeria	319
MACFIE, J. W. S.	
Ceratopogoninae from Dar-es-Salaam	355
MACGREGOR, M. E.	
Some Effects of Electric Current on Mosquito Development ...	315
MARSHALL, G. A. K.	
New Curculionidae attacking Cultivated Plants (Col.)	67
POSPELOV, V. P.	
The Influence of Temperature on the Maturation and General Health of <i>Locusta migratoria</i> , L.	363
PROUT, L. B.	
A New Geometrid Moth attacking Deodars in India	377
SENIOR-WHITE, R.	
Physical Factors in Mosquito Ecology	187
STACKELBERG, A.	
Notes on the Genus <i>Chrysops</i> (Diptera, Tabanidae)	325
SWYNNERTON, C. F. M.	
The Tsetse-fly Problem in the Nzega Sub-District, Tanganyika Territory	99
TRÄGÅRDH, I.	
Entomological Analyses of Trees	169
UVAROV, B. P.	
A New Grasshopper injurious to Rice in Siam	159
WATERSTON, J.	
On a New Trichogrammatid (Hym. Chalcidoidea) Parasite of the Cotton Stem-borer (<i>Sphenoptera</i> sp.)	309
WHITFIELD, F. G. S.	
The Natural Control of the Leaf-miner <i>Phytomyza aconiti</i> , Hendl (Diptera) by <i>Tachydromia minuta</i> , Mcigen (Diptera)	95
WIMSHURST, F. M.	
The Cherry Black Fly (<i>Myzus cerasi</i>)	85

MISCELLANEOUS.

Collections received	111, 185, 291, 407
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ERRATA

Page	39 line 4 for " <i>Erencytrus</i> " read " <i>Erencyrtus</i> "
"	45 line 3 for " Griffiths " read " Griffiths "
"	49 line 14 for " GRIFFITH " read " GRIFFITHS "
"	91 line 9 for " <i>serratula</i> " read " <i>serrulata</i> "
"	149 line 10 for " (1922) " read " (1923) "
"	157 6 lines from end for " Soc." read " Ser."
"	173 7 lines from end for " <i>Pityphthorus</i> " read " <i>Pityophthorus</i> "
"	229 line 30 for " Johnson " read " Johnstone "
"	252 line 13 for " <i>Diatarea</i> " read " <i>Diatraea</i> "
"	268 9 lines from end for " Dr. C. B. Baker " read " Dr. A. C. Baker "
"	326 line 26 for " <i>mlokosiewiczzi</i> " read " <i>mlokosiewiczzi</i> "
"	329-346 <i>passim</i> for " <i>Tectacoris</i> " read " <i>Tectocoris</i> "
"	337 note for " C. J. Withycombe " read " C. L. Withycombe "

BULLETIN
OF
ENTOMOLOGICAL RESEARCH.

VOL. XVI.

1925.

A CONTRIBUTION TO KNOWLEDGE OF THE BLOOD-SUCKING
DIPTERA OF THE DARDANELLES.

By MAJOR E. E. AUSTEN, D.S.O.

Although, among the very numerous species of Diptera described by the late Dr. Hermann Loew, the types of not a few are stated to have been obtained in Asia Minor, nothing whatever relating directly to the Diptera of the Dardanelles has hitherto appeared in print. A paper by Loew on a collection of Diptera made near Varna* is, however, worth bearing in mind in connection with any future work on the Dipterous fauna of the Dardanelles. The paper in question includes records of seven species of TABANIDAE, some of which are among those mentioned in the following pages.

The present contribution is based upon two small collections, one of which was made in Gallipoli by Major W. M. J. Martin, late R.A. ; while the other was formed on the Asiatic shore, near Chanak, by Major A. D. Fraser, D.S.O., M.C., R.A.M.C. The specimens in both cases were caught while their captors were serving with the Army of the Black Sea, and were subsequently presented by the collectors to the British Museum. Except where otherwise stated, all material referred to in the following pages was collected by Major Fraser. Seeing that environmental and other conditions in the vicinity of Chanak are probably closely similar to those in Gallipoli itself, it is somewhat curious that, while two species of *Pangonius* were found by Major Martin in Gallipoli, none was met with by Major Fraser on the other side of The Narrows. The occurrence of a new species of the genus *Silvius* in Gallipoli is of special interest.

Subjoined is a list of all the species recorded or described in the present paper ; it will be seen that the total amounts to 38, and that 7 of these are apparently new.

All the material mentioned, including the types of new species, is in the British Museum (Natural History).

* H. Loew, " Ueber einige bei Varna gefangene Dipteren " : Wien. Ent. Monatschr., vi, 6, pp. 161-175 (June 1862).

LIST OF SPECIES RECORDED OR DESCRIBED BELOW.

Culicoides guttularis, Kieff.
Culicoides nubeculosus, Meig.
Aedes detritus, Hal.
Aedes argenteus, Poir.
Aedes caspius, Pall.
Taeniorhynchus richiardii, Fic.
Theobaldia longiarcolata, Macq.
Theobaldia annulata, Schr.
Culex hortensis, Fic.
Culex pipiens, Linn.
Anopheles bifurcatus, Linn.
Anopheles maculipennis, Meig.
Anopheles superpictus, Grassi.
Simulium pulchripes, sp. n.
Phlebotomus papatasi, Scop.
Phlebotomus minutus, Rond., var. *africanus*, Newst.
Pangonius haustellatus, Fabr.
Pangonius pyritosus, Lw.
Silvius inflaticornis, sp. n.
Chrysops caecutiens, Linn., var. *meridionalis*, Strobl.
Chrysops italica, Meig.
Chrysops flavipes, Meig.
Haematopota fraseri, sp. n.
Haematopota latebricola, sp. n.
Haematopota belligera, sp. n.
Tabanus ater, Rossi.
Tabanus spectabilis, Lw.
Tabanus roussellii, Macq.
Tabanus lunatus, Fabr.
Tabanus umbrinus, Meig.
Tabanus leleani, Austen.
Tabanus fraseri, sp. n.
Tabanus oppugnator, sp. n.
Stomoxys calcitrans, Linn.
Lyperosia irritans, Linn.
Lyperosia titillans, Bezzi.
Hippobosca equina, Linn.
Lipoptena caprina, Austen.

Family CHIRONOMIDAE.

Subfamily CERATOPOGONINAE.

Genus **Culicoides**, Latr.**Culicoides guttularis**, Kieff.

One ♀, Dardanelles, near Chanak, summer 1923.

In spite of certain abnormalities in the wing-markings (e.g., the shape of the pale spot on the costal border immediately beyond the tip of the third longitudinal vein; the open communication of this spot with the one below it; and the fact that the distal extremity of the latter is closer to the tip of the wing than usual), the determination given above is in all probability correct. The condition of the solitary specimen available for study is, however, so faulty that absolute certainty is impossible.

For notes on the distribution of *C. guttularis*, which, besides occurring in Palestine, is also found in Hungary and Great Britain (*cf.* Austen, Bull. Ent. Res., xii, pt. 2, p. 114, September 1921).

***Culicoides nubeculosus*, Meig.**

Seven ♀♀, Dardanelles, near Chanak, summer 1923.

This species, which is known to bite severely, is widely distributed in the Palaearctic Region, its area extending from Scandinavia, through Central and Southern Europe, at least as far as the Euphrates. In addition to a series of specimens from various localities in England, Wales and Scotland, the National Collection includes a ♀ from Macedonia (near Salonika, Lutra Marshes, 18. viii. 1918, *Dr. C. M. Wenyon, C.M.G., C.B.E.*), and another from Iraq (Basra district, October 1919, *Captain P. J. Barraud*: presented by the Imperial Bureau of Entomology). The two latter examples agree with Major Fraser's specimens from the Dardanelles in the pale (milky) areas in the wings being more extensive than is usually the case in British representatives of *C. nubeculosus*, but there do not appear to be any other differences worth mentioning.

In a field-note, which includes the foregoing as well as the present species, Major Fraser writes: "Troublesome in the hills about two miles north of Chanak, which bear a fair number of oak-like trees."

Family CULICIDAE.*

Genus ***Aedes***, Meig.

Aedes detritus, Hal.

One ♂, one ♀, Dardanelles, near Chanak, summer 1922 and 1923.

Aedes argenteus, Poir.

One ♀, Dardanelles, near Chanak, summer 1923.

Aedes caspius, Pall.

Four ♂♂, four ♀♀, Dardanelles, near Chanak, summer 1923.

A note by Major Fraser, attached to two of the ♀♀, states that they were "bred in September, from larvae in a filthy brackish pool."

Genus ***Taeniorhynchus***, Arrib.

Taeniorhynchus richiardi, Fic.

Two ♀♀, Dardanelles, near Chanak, summer 1923.

Genus ***Theobaldia***, Nev.-Lem.

Theobaldia longiareolata, Macq.

Two ♂♂, six ♀♀, Dardanelles, near Chanak, summer 1922 and 1923.

Theobaldia annulata, Schr.

Two ♀♀, Dardanelles, near Chanak, summer 1922.

Genus ***Culex***, Linn.

Culex hortensis, Fic.

One ♀, Dardanelles, near Chanak, summer 1922.

* Determinations kindly supplied by Mr. F. W. Edwards.

Culex pipiens, Linn.

Six ♂♂, eleven ♀♀, Dardanelles, near Chanak, summer 1922 and 1923.

Genus **Anopheles**, Meig.*Anopheles bifurcatus*, Linn.

One ♂, two ♀♀, Dardanelles, near Chanak, summer 1922 and 1923.

Major Fraser writes that this species is "common at Chanak early in July."

Anopheles maculipennis, Meig.

Three ♂♂, two ♀♀, Dardanelles, near Chanak, summer 1923.

According to the donor, *A. maculipennis* "appeared in large numbers in tents near the Hospital, for a short time early in July."

Anopheles superpictus, Grassi.

Five ♂♂, five ♀♀, Dardanelles, near Chanak, summer 1923.

Major Fraser's field note on these specimens of *A. superpictus* states that they were "bred at the end of August, from larvae taken from small pools at the edge of the Kaja Chai," a small river flowing into the Dardanelles at Chanak.

Family SIMULIIDAE.

Genus **Simulium**, Latr.**Simulium pulchripes**, sp. n.

♀. Length (7 specimens), 1.6 to 2.2 mm.

Dorsum of thorax slate-black,* *silvery-grey on each side*; *dorsum of abdomen at base* ivory-yellow or pinkish-buff, then sooty-black, and at distal extremity shining slate-black; *legs* mainly cinnamon-buff or cream-buff, *tips of tibiae and tip of first segment of middle and hind tarsi*, as also *remaining segments of middle and hind tarsi except base of second*, dark brown or blackish-brown, *femora* sometimes with brownish infuscations; *front tarsi* black, *first three segments* strongly expanded; *all claws* simple.

Head: *front* (frons) in ♀ shining bronze-green, rather broad above (measured on margin of vertex about four-fifths as broad as long), but narrowing rapidly from above downwards, apparently clothed normally with minute, glistening, yellowish hairs; *clypeus* shimmering silvery-white pollinose, clothed, at least below, with hairs similar to those on front; *palpi* blackish-brown or black, clothed with blackish hair; *antennae* orange-cinnamon at base, and on under-surface for some distance towards tip, blackish brown elsewhere. *Thorax*: *dorsum* somewhat shining posteriorly, humeral calli and a stripe on each side of fore part of main portion of *dorsum* (scutum), commencing on fore border, curving round humeral callus, and tapering off and terminating in front of base of wing, silvery-grey pollinose (visible only from certain angles); *dorsum* clothed with minute, appressed, glistening, Naples yellow hairs, long hairs fringing margin of scutellum blackish-brown; *meso- and sternopleurae* silvery-grey pollinose. *Abdomen*: *abdominal scale* (first tergite) and following tergite ivory-yellow (in dried specimens often pinkish buff), hind border of second tergite blackish-brown, at least on each side; next three tergites sooty-black; distal extremity of abdomen (last four tergites) shining slate-black; fringe

* For names and illustrations of colours used for descriptive purposes in the present paper, see Ridgway, "Color Standards and Color Nomenclature" (Washington, D.C. Published by the Author, 1912).

of hair on abdominal scale Naples yellow, glistening. *Wings* normal, costa and adjacent veins cream-buff. *Halteres* ivory-yellow. *Legs*: femora sometimes with distal halves, or rather more, dark-brown or brownish (in case of front pair, which bears some longish hairs on extensor surface, infuscation when present may be represented by an incomplete annulate mark before tip); tibiae, except tips, ivory-yellow, with a silvery shimmer on extensor surface, at least in case of front and middle pairs, infuscated tips of hind tibiae darker in some individuals than in others, and also sometimes deeper, occupying as much as distal third of segment; first segment of front tarsi in length about equal to combined length of remaining segments; first segment of hind tarsi not expanded, last four segments of hind tarsi together equal in length to about three-fourths of first segment, second segment nearly twice as long as third, and with a distinct dorsal excision.

Holotype and six paratypes, Dardanelles, near Chanak, summer 1923. Major Fraser's field note on this species runs: "Found in the early morning in June, in the bed of the Koja Chai, a small river flowing into the Dardanelles at Chanak."

As regards colouration of the legs, the species described above somewhat resembles *Simulium schönbaueri*, Enderl. (Sitzgsber. Ges. naturf. Freunde, Jahrg. 1920, Nr. 8-10, p. 218, 1921), which was described from two ♀♀ from Northern Czechoslovakia. Apart, however, from its smaller size, the new species is distinguishable from the one referred to by the absence of thoracic stripes, and the (relatively) more strongly expanded front tarsi.

Family PSYCHODIDAE.

Genus *Phlebotomus*, Rond.

Phlebotomus papatasi, Scop.

Four ♂♂, seven ♀♀, Dardanelles, near Chanak, 1922, 1923.

Phlebotomus minutus, Rond., var. *africanus*, Newst.

Six ♂♂, eight ♀♀, Dardanelles, near Chanak, 1922, 1923.

According to a note by Major Fraser, the sandflies taken by him in 1922 were caught in the Hospital buildings. So far as present information goes, the species and variety recorded above are the only representatives of the genus *Phlebotomus* found in Asia Minor: for observations on their occurrence in Palestine, cf. Austen, Bull. Ent. Res., xii, pt. 2, pp. 118-120 (September 1921).

Family TABANIDAE.

Subfamily PANGONIINAE.

Genus *Pangonius*, Latr.

Pangonius haustellatus, Fabr.

Tabanus haustellatus, Fabricius, Species Insectorum, ii, p. 455 (1781).

Pangonia marginata, Fabricius, Systema Antliatorum, p. 90 (1805).

One ♂, two ♀♀, Gallipoli, June-July 1923, "common everywhere" (Major W. M. J. Martin).

The arbitrary and entirely unnecessary action of Fabricius (Syst. Antl., loc. cit.) in substituting, 24 years after the species was originally described, the name *marginata* for *haustellatus*, has been approved and copied by all subsequent writers,

including both Kröber and Szilády;* the restoration, however, of the older designation, as given above, is in accordance with the accepted Law of Priority.

In spite of the fact that the type of the species, originally in the possession of Sir Joseph Banks, is no longer to be found in the Banksian Collection, which is preserved in the British Museum (Natural History), there can be no doubt as to the correctness of the identification here recorded. It may, however, be added that the ♀♀ obtained by Major Martin appear to belong to the var. *tenuipalpis*. Kröber (Archiv f. Naturgesch., 87. Jahrg., Abt. A, 1. Heft, p. 16, December 1921).

Pangonius pyritosus, Lw.

Two ♀♀, Gallipoli (Gaba Tepe), July-August 1923, "very common in open country" (Major W. M. J. Martin).

The type of this species, which presents a deceptive similarity to the foregoing, but may be distinguished in the case of both sexes by the shorter face, and in the ♀ by the terminal segment of the palpus being shorter and broader, *i.e.*, deeper, was obtained at Brusa in Asia Minor. With the exception of a narrow, curved, orange-cinnamon area extending from front to hind margin of the second (visible) tergite, near each of its lateral extremities, the ground-colour of the dorsum of the abdomen in both Major Martin's examples is mainly olivaceous black.

Genus **Silvius**, Meig.

The sole representative of this genus in the present collection is a much damaged and almost completely denuded female from Gallipoli, which presents more than one structural feature of interest, and appears to belong to an undescribed species. In spite of the condition of the specimen, it seems desirable on account of the imperishable memories attaching to its place of origin, as also by reason of the peculiarities of structure in question, to attempt the following characterisation, which, with the accompanying figures, it is hoped will enable the species to be recognised.

Silvius inflaticornis, sp. n. (fig. 1).

♀. Length (one specimen), 10 mm.; width of head, 3 mm.; width of front at vertex, 1 mm., across lower edge of frontal callus, 1.25 mm.; length of wing, 9 mm.

N.B.—In the case of the typical specimen, excessive exposure to damp during the process of pinning or mounting has caused the more or less complete disappearance of pollinose covering, while the dark areas on head, thorax and abdomen, instead of being greyish-olive or dark greyish-olive, as is very possibly the case in life, are sooty black.

Front (frons) rather broad and conspicuously broader below, with shining black callus somewhat cordate or roughly triangular in outline, with upwardly-directed apex; front, subcallus and face, when head is viewed in profile, somewhat prominent; eyes clothed with minute hairs; first segment of antenna noticeably incrassate; dorsum of abdomen (in case of type) for most part black, but lateral extremities of first three (visible) tergites ochraceous-tawny; wings with light but distinct sepia-coloured tinge; legs (so far as visible in case of type) for most part ochraceous-tawny.

Head: occipital borders deep (as seen when head is viewed from above); front (frons), occiput and jowls in case of type, sooty-black, jowls with a trace of olive-grey

* Cf. O. Kröber, "Die paläarktischen Arten der Gattung *Pangonia* Latr. (Versuch einer Auseinandersetzung)"; Archiv f. Naturgesch., 87. Jahrg., Abt. A, 1. Heft, pp. 1-67, 20 figs. in text (December 1921).

Cf. also Z. Szilády, Biologica Hungarica, Vol. i, Fasc. 1, p. 23 (1923).

or smoke-grey pollinose covering; ground-colour of subcallus and face vinaceous-buff or pinkish cinnamon, but central area and lateral extremities of subcallus infuscated; face, jowls and proximal segment of palpi clothed with fine pale yellowish hair; *ocelli* in ♀ rather wide apart, anterior ocellus further from posterior pair of ocelli than latter are from each other; proximal segment of *palpi* dusky, distal segment orange-cinnamon-coloured, laterally compressed and knife-shaped; first and second segments of *antennae* dark mouse-grey (third segment missing in case of type), orange-cinnamon-coloured on inner side of base in each case, first segment distinctly swollen, more or less cylindrical, its inner margin as seen from above strongly convex (cf. fig. 1, *a* and *b*), second segment small and somewhat rounded,

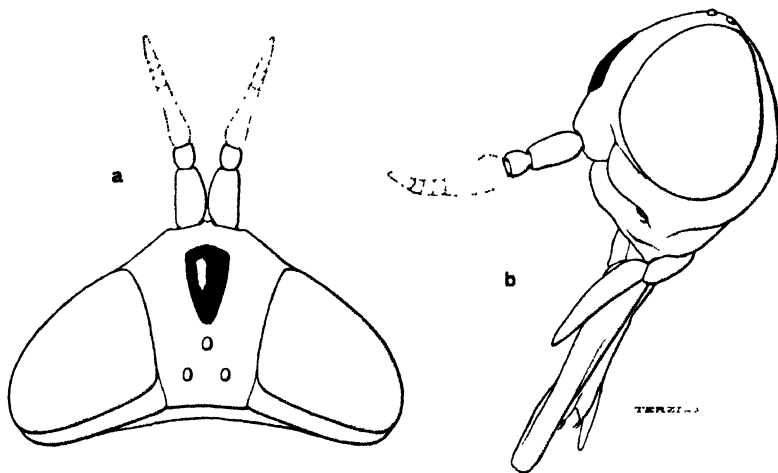


Fig. 1. Head of *Silvius inflaticornis*, Austen, ♀: *a*, from above; *b*, in profile. $\times 16$.

little more than one-third of length of first segment, both first and second segments sparsely clothed below with fairly long, brownish or blackish hair. *Thorax*: dorsum, including scutellum, in case of type discoloured, sooty-black, entirely devoid of markings and almost completely denuded, but with pale yellow (Naples yellow or straw yellow) hairs on lateral borders of scutum; pleurae and pectus dark mouse-grey or dark neutral grey, clothed with Naples yellow or straw yellow hair. *Abdomen*: hind borders of second (visible) and following tergites, as well as lateral margins in case of fourth and succeeding tergites, yellowish (dark olive-buff); lateral extremities of first three tergites clothed with pale yellowish hair (remainder of dorsum completely denuded in case of type); ground-colour of venter agreeing generally with that of dorsum, though ochraceous-tawny lateral extremities of first three sternites rather more extensive than those of corresponding tergites; venter clothed for most part with fine, Naples yellow hair. *Wings*: veins for most part mummy-brown, fifth and sixth longitudinal veins, and base of anterior branch of former paler (ochraceous-buff); anterior branch of third longitudinal vein, at least in case of type, without slightest trace of an appendix; *anal cell open*; *stigma* cinnamon-rufous, narrow, elongate and fairly conspicuous. *Squamae* cream-buff, small and inconspicuous. *Halteres* cream-buff, distal extremities of knobs slightly brownish. *Legs*: coxae and trochanters iron-grey, front coxae ochraceous-buff at base; tips of all femora blackish-brown, femora likewise blackish-brown or brownish at extreme base; extremities of front tibiae coloured like those of front femora (middle tibiae missing in case of type), hind tibiae dark brown only at tips, apical spines of moderate size; front tarsi uniformly blackish-brown (middle tarsi missing in case of type), hind tarsi blackish-brown, first segment, except tip, paler (mummy brown); coxae and femora clothed for most part with pale yellowish hairs, front

femora also with blackish hairs below; front and hind tibiae clothed partly with minute, appressed, Naples yellow and partly with black hairs; front and hind tarsi clothed above with minute black hairs.

Gallipoli, near Anzac Cove, July 1923 (*Major W. M. J. Martin*).

Owing to the swollen first antennal segment and open anal cell, *Silvius inflaticornis* cannot be confused with any of its congeners as yet described. The shape of the first segment of the antenna, in conjunction with the prominence of the anterior portion of the head, may perhaps indicate a certain approximation to the genus *Surcoufia*, Kröber (Arch. f. Naturgesch., 88. Jahrg., Abt. A, 8. Heft, p. 116, 1922), the genotype of which, and as yet the only species known, is *S. paradoxa*, Kröber (*ibid.*), which was described from males from Tunis and Morocco. In *Surcoufia*, however, the first segment of the antenna is still more strongly swollen, being nearly spherical (only about a quarter longer than broad), while the proboscis is short (approximately as long as the head). In *Silvius inflaticornis*, on the other hand, the proboscis is considerably longer than the head.

Genus **Chrysops**, Meig.

Chrysops caecutiens, Linn., var. **meridionalis**, Strobl.

One ♀, Dardanelles, near Chanak, August 1922. The donor's field-note on this specimen runs: "Caught among the hills 3 miles S. of Kephez, a village 5 miles S. of Chanak, at the end of August, on myself."

This variety was previously represented in the British Museum by a ♀ from Bulgaria, Touria near Kazanlik, 1.viii.1906 (*Prof. Schischkoff*).

Chrysops (Heterochrysops) italica, Meig.

Thirteen ♀♀, Dardanelles, near Chanak, August 1922; two ♀♀, close to Chanak, on horse, summer 1923.

Major Fraser's field notes include the following observation with regard to *C. italica*: "This species was common during the summer about a mile north of Nagara Point, near a small pool of dirty, brackish water, surrounded by rushes, and separated from the sea by a bank of shingle a few yards wide."

Writing of *C. italica* in 1858, Loew states (Verh. z.-b. Ges. Wien, viii, p. 631, note 1) that it is very common in all parts of South Europe, especially Italy, and that its range extends eastwards as far as Asia Minor, while northward its area includes South Germany. The National Collection contains specimens of this species from the Grecian Archipelago, Cyclades (presented by Miss Ricardo); Macedonia, 1918 (*Dr. C. M. Wenyon*, C.M.G., C.B.E.); Albania (*E. Doubleday*); Cyprus (*W. H. Bennett*); and Cyprus, Nicosia (*Miss D. M. A. Bate*).

Chrysops flavipes, Meig.

Six ♀♀, Dardanelles, near Chanak, August 1922; five ♀♀, close to Chanak, on horse, summer 1923.

As to *C. flavipes*, Major Fraser writes: "Found near Koja Chai, a small river which flows into the Dardanelles at Chanak. Although the spots where this and the foregoing species [*Chrysops italica*, Meig.] were met with were only about three miles apart, each species seemed to be strictly confined to its own particular locality."

In the ♀ of this species, as shown by the series of specimens obtained by Major Fraser, the colouration of the hind femora is subject to considerable variation, ranging from ochraceous-buff with the extreme tips dark brown, through various gradations, to black or olivaceous black.

Three Bulgarian ♀♀ of *C. flavipes* (from Pavel-Bania, near Kazanlik, 13.viii.1906, Prof. Schischkoff) already in the British Museum have the hind femora olivaceous black, with in two instances a more or less distinct small russet-coloured area before the tips.

Subfamily TABANINAE.

Genus *Haematopota*, Meig.

No examples of *Haematopota* were included among the Diptera brought back by Major W. M. J. Martin from Gallipoli, while only three were contained in the collection formed on the Asiatic shore of the Dardanelles during 1922-23 by Major A. D. Fraser, according to whom the genus was by no means common in the vicinity of Chanak. Major Fraser's specimens, all of which are females, prove to belong to three distinct species, which are described below as new, since all alike are indeterminable by means of Kröber's useful tables for the identification of the Palaearctic forms of *Haematopota* known to him (Arch. f. Naturgesch., 88. Jahrg., Abt. A, 8. Heft, pp. 138-140, 1922), while it has proved equally impossible to determine them with the aid of other literature, including Szilády's "*Palaearctic Haematopotae*" (Biologica Hungarica, i, 1, pp. 31-39, 1923).

In this connection may be noted a curious parallel with the collection formed by the author in 1918, in Palestine, wherein, out of 28 specimens of *Haematopota* belonging to four species—all new, three females each represented a distinct species (cf. Austen, Bull. Ent. Res., x, 3, p. 280, April 1920).

Key for the mutual distinction of the Species described below (♀♀ only):—

- 1 (2). First segment of antenna, viewed from side, with a deep preapical groove or constriction on upper surface *fraseri*, sp. n.
- 2 (1). First segment of antenna without such a groove
- 3 (4). First segment of antenna, viewed from side, uniformly cylindrical, entirely dull *latebricola*, sp. n.
- 4 (3). First segment of antenna, viewed from side, considerably swollen, skittle-shaped, shining black at tip *belligera*, sp. n.

Haematopota fraseri, sp. n. (fig. 2).

♀. Length (one specimen), 11.25 mm.; width of head, 4 mm.; width of front at vertex, 1.4 mm.; length of wing, just under 9 mm.

Nearly allied to, and, in ♀ sex at least, closely resembling H. italica, Mg., from which it is distinguishable in ♀ sex by distal halves of front tibiae being much more strongly swollen.

Head: front, light greyish olive, lateral margins, a narrow border encircling each frontal spot, and a well-marked median line from vertex to border surrounding median frontal spot paler (smoke-grey or pale smoke-grey), an oblique transverse mark in each lateral paller, extending from lateral margin to border surrounding median frontal spot, greyish-olive; face and jowls greyish white pollinose, sides of face punctate in usual manner, pair of dark spots on central region of face distinctly marked; occiput pallid neutral grey; hair on hind margins of upper portions of posterior orbits yellowish, that on vertical region, and on greyish olive transverse marks on front, black or blackish, and that on face and jowls whitish; frontal spots (cf. fig. 2, a) dead black or blackish brown, median spot distinct, lateral spots large, roughly oval, not in contact with eyes; *frontal callus* (cf. fig. 2, a) shining black, of moderate and practically uniform depth, in contact with eye on each side below, its upper margin produced into a low angle in middle line; usual spot in middle line

below callus dull black, large but not conspicuous, its depth about equal to its width on upper margin; *eyes* clothed with minute, short, whitish hair; *palpi* pinkish-buff (terminal segment whitish-pollinose, considerably swollen towards base), proximal segment, and base of terminal segment above and below, clothed with long white hair, outer surface of terminal segment, as well as upper surface beyond basal fourth, clothed with minute, appressed, glistening creamy-white hair, mixed with minute black hair; first segment of *antennae* (cf. fig. 2, *b*) cylindrical, not swollen, about four and a half times as long as its vertical diameter in middle, with a deep constriction before its distal extremity, blackish-brown and more or less distinctly greyish-pollinose (ground-colour on inner side of proximal two-thirds russet), clothed above and on distal extremity with short black hair, and below with longer whitish hair; second segment of antennae dusky, with a slight tinge of russet below, greyish-pollinose, clothed with short black hair, and with its upper angle produced and closely embracing base of third segment; expanded portion of latter cinnamon-brown, as viewed from side, not very deep, its vertical diameter at its deepest scarcely greater than that of distal extremity of first segment, annulate portion of third segment

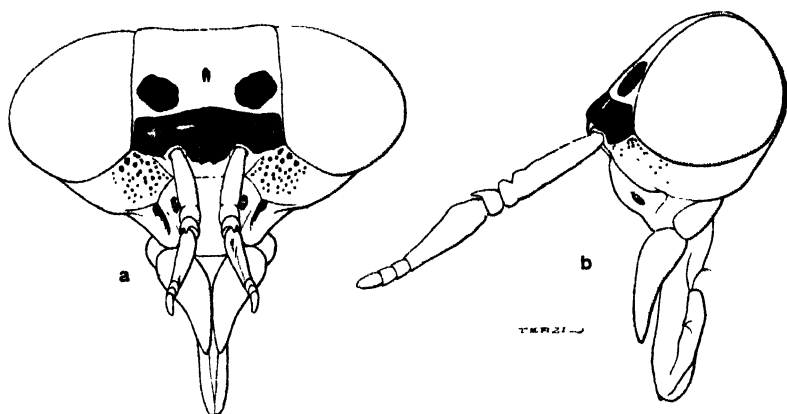


Fig. 2. Head of *Haeamatopota fraseri*, Austen, ♀: *a*, from in front; *b*, in profile. $\times 14$.

sooty-black, its length but little more than half that of expanded portion. *Thorax*: dorsum, including scutellum, iron-grey or olivaceous black, clothed with short, glistening, Naples yellow hair (dorsum of scutum in case of type perhaps discoloured, with no trace of usual pale olive-grey, longitudinal stripes, other than a vestige, on each side of middle line, of usual triangular mark behind transverse suture, and two broad, dark olive-grey, admedian, longitudinal stripes in front of latter); antealar tubercle on each side light drab, pale smoke-grey pollinose, and clothed for most part with outstanding black hair; lateral border of scutum on each side behind antealar tubercle pale olive-grey pollinose; pleurae and pectus pale olive-grey pollinose, clothed with long white hair. *Abdomen*: dorsum olivaceous-black, with a narrow and continuous, median, smoke-grey, longitudinal stripe, commencing on second (visible) tergite as a forwardly directed triangle, which does not reach front margin, and a double series of similarly coloured, rounded spots, two of which are present on each visible tergite; hind borders of second and following tergites smoke-grey, their extreme hind margins cream-buff; middle third of anterior border of second tergite smoke-grey; lateral extremities of all tergites broadly pale olive-grey; dorsum clothed mainly with short, appressed, black hair, with longer white hair on lateral extremities of first two and last two tergites, and with short whitish or yellowish hair on or near hind borders of third to fifth tergites inclusive, at least towards their lateral extremities; venter pale olive-grey (third to sixth sternites inclusive more or less greyish-olive or deep greyish-olive in centre), with cream-buff hind margins to

second and following sternites; venter clothed with short, glistening, yellowish or cream-coloured hair, and with usual patch of coarse, erect, black hair in centre of terminal sternite. *Wings* pale mouse-grey, with light markings clear and distinct, all three rosettes being well-defined, with adjacent margins of proximal and middle rosettes, where they cross discal cell, not fused together; apical sinuous mark (pale transverse streak just before apex of wing) distinct, and continued right along hind border into apex of axillary cell, with usual series of light markings between hind border and rosettes extending from second submarginal to fifth posterior cell inclusive; veins sepia-coloured (veins or portions of veins enclosed within rosettes only slightly darker), auxiliary vein and proximal portions of second and fifth longitudinal veins tawny-olive; *stigma* mummy-brown, well-defined, elongate and conspicuous, its proximal extremity paler; no dark blotch beneath stigma. *Squamae* pale smoke-grey, with cream-buff borders fringed with pale hair. *Halteres* cream-buff, knobs with a clove-brown patch, not connected with its fellow, above and below. *Legs*: coxae olive-grey pollinose, clothed with white hair; trochanters olivaceous-black; femora pale olive-grey pollinose, clothed with white or whitish hair and towards distal extremities with short black hair, middle femora at least, above and posteriorly, with a more or less distinct light ochraceous-salmon-coloured area, beyond proximal third, but not extending to distal extremity; rather less than proximal half of front tibiae (except extreme base, which is faintly brownish) creamy-white, remainder black and conspicuously swollen, front margin of black portion, when leg is viewed from side, strongly convex, creamy-white area clothed with appressed, glistening, silvery hair, which on inner and outer surfaces extends for some distance on to black area, latter being otherwise clothed with short, black hair; middle and hind tibiae clove-brown, in each case with two cream-buff bands, which thus give rise to three dark bands—a narrower, fainter and less conspicuous band just beyond base, and two darker, deeper and much more noticeable bands, one in centre and one at distal extremity; middle tibiae clothed mainly with glistening silvery hair, but also with short black hairs on dark bands and especially at distal extremity; hind tibiae clothed similarly to middle pair, fringe on extensor surface conspicuous and mainly silvery, except on distal dark band, where it is entirely black; front tarsi uniformly black, middle and hind tarsi (except proximal three-fourths of first segment of middle tarsi, and rather more than proximal half of corresponding segment of hind tarsi, which are cinnamon-buff) clove-brown; tarsi clothed mainly with short, black hair, with longer and paler hairs on sides of distal extremities of segments in case of front pair.

Dardanelles, near Kephez village, 5 miles south of Chanak, early in June 1922.

Were it not for the front tibiae, at least in the ♀ sex, the species just described, which is named in honour of its discoverer, might pass for a variety of *H. italica*, Meig. (cf. Kröber, Arch. f. Naturgesch., 88. Jahrg., Abt. A, 8. Heft, pp. 145–149, 1922). On the other hand, in shape and colouration of the front tibiae of the ♀, *H. fraseri* is reminiscent of *H. minuscularia*, Austen (Bull. Ent. Res., x, 3, p. 285, fig. 4, a, April 1920), of Palestine, from which, however, it is distinguishable, *inter alia*, by antennal characters, as well as by its much larger size.

***Haematopota latebricola*, sp. n. (fig. 3).**

♀. Length (one specimen), 10.4 mm.; width of head, 3.6 mm.; width of front at vertex, 1.2 mm.; length of wing, 9 mm.

Antennae (at least in ♀) entirely dark, first segment dull, dark olive-grey pollinose, not at all shining, cylindrical and moderately swollen, with no constriction before distal extremity, considerably stouter than third segment (stouter than it appears in fig. 3, b); *dorsum of abdomen* with a double series of conspicuous, pale smoke-grey spots commencing on third segment, and a fainter pair of spots on second (visible) segment; *wings* pale smoke-grey, pale markings rather coarse except near hind borders.

Head: front smoke-grey, lateral margins, especially above, lighter (pale smoke-grey), but (at least in case of type) no light borders encircling frontal spots, and no conspicuous light median line connecting median spot with vertex; face and jowls greyish white pollinose, sides of face moderately punctate above, but pair of dark spots below antennae scarcely noticeable, small, narrow and indistinct; occiput pallid neutral grey, hind borders of posterior orbits above with slightly olivaceous tinge; hair on hind borders of posterior orbits yellowish above, whitish below, vertical region and frontal spots clothed with short, erect black hair, front otherwise clothed with appressed pale hair, face, jowls and lower portion of occiput clothed with white hair; frontal spots (*cf. fig. 3, a*) blackish brown, median spot paler and indistinct, lateral spots wider above than below and each, at least in case of type, with its upper border produced outwards and downwards towards inner margin of adjacent eye, which, however, it does not reach; *frontal callus* (*cf. fig. 3, a*) shining black, moderately deep in centre, where its upper margin is produced into a slight angle, but diminishing in depth towards each lateral extremity, which below is just in contact with, or very narrowly separated from, corresponding eye; spot in middle line below callus

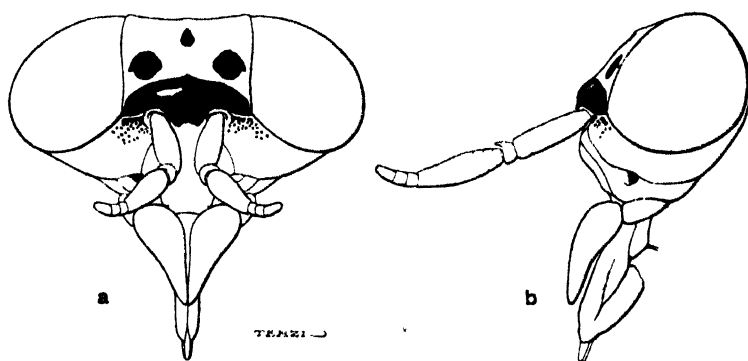


Fig. 3. Head of *Haematopota latebricola*, Austen, ♀: *a*, from in front; *b*, in profile. × 14.

blackish brown, dull, wider than deep, conspicuous; *eyes* clothed with minute, pale hair; proximal segment of *palpi* pale neutral grey, clothed on outer surface and below with long white hair, terminal segment drab-grey (pale drab-grey at base), not much swollen basally, clothed on outer side with glistening, appressed, whitish hair, and with longer hair of similar colour on proximal portion of under surface; first segment of *antennae* (*cf. fig. 3, b*) in ♀ about three times as long as its vertical diameter in centre, clothed above and on outer surface with short black hair, and below with whitish hair; second and third segments of antennae blackish-brown (third segment slightly paler at base on inner side), second segment small, clothed with minute black hairs, third segment slender, its expanded portion about twice as long as annulate portion, but equal to little more than half of first segment in depth. *Thorax*: dorsum of main portion (scutum) blackish mouse-grey, with usual light neutral grey longitudinal markings well-defined, at least in front of and for part of distance behind transverse suture, after which, with exception of their extremities, outer stripes are obliterated, at any rate in case of type; median stripe (in case of type) not reaching prescutellar groove; lateral borders of scutum pale olive-grey pollinose; dorsum, including hind border, of scutellum deep olive-grey, with a large, triangular, dark olive-grey patch on each side, resting on base and with its apex nearly reaching hind margin; dorsum, including scutellum, clothed with short, more or less appressed, olive-buff hair (longer on scutellum), on posterior half of scutum interspersed with black hair, a patch of short black hairs also on each

lateral border, immediately behind antealar tubercle; pleurae and pectus pale olive-grey pollinose, clothed with fine greyish white hair. *Abdomen*: dorsum olivaceous-black, lateral extremities of tergites pale olive-grey pollinose, hind borders and a median longitudinal stripe, commencing as a narrow triangle on second (visible) tergite, and extending to hind margin of penultimate tergite, pale smoke-grey, spots on fourth (visible) and two following tergites elongate and resting on front margins of segments; dorsum clothed partly with short black, partly with whitish hair, appressed or decumbent, except in case of whitish hair on lateral extremities of tergites; venter pale olive-grey pollinose, clothed with short, appressed whitish hair, terminal sternite with usual patch of longer, coarse, erect black hair in centre, preceding sternite also with shorter black hairs on corresponding area. *Wings*: ground-colour pale smoke-grey, all three rosettes distinct and, at least in case of type, light markings forming proximal rosette and inner margins of median and distal rosettes rather coarse; discal cell in centre with two transverse light markings, which are not fused together; pale loop in marginal cell at distal extremity of stigma, and sinuous mark or transverse streak just before apex of wing distinct, but, at any rate in type, no pale border running along hind margin; veins mummy-brown, tip of auxiliary vein and proximal portions of second and fifth longitudinal veins paler; *stigma* mummy-brown, small and rather short, its proximal extremity pale. *Squamae* cream-coloured. *Halteres* cream-buff, knobs chocolate-brown at base on each side. *Legs*: front tibiae, at any rate in ♀, not at all swollen; coxae greyish-white pollinose, clothed, like trochanters and femora, with greyish-white hair; trochanters iron-grey; femora pale olive-grey pollinose, ground-colour of front pair darker (dark olive-grey); front tibiae cream-buff, distal fourth black or brownish black, preceded by an ill-defined brownish band across middle; (middle tibiae missing in case of type) hind tibiae rather broad (compressed in an antero-posterior direction), clove-brown or blackish brown, with two cinnamon-buff bands, one on each side of middle third; front tibiae clothed with minute, appressed, whitish hair (distal extremity with minute black hair), and with some longer black hairs in middle of extensor surface; hind tibiae clothed mainly with whitish hair, which forms a conspicuous fringe on extensor surface, fringe also mixed with black hairs beyond base as far as distal extremity of middle dark band, and on apical dark band, which is clothed mainly with black hairs; front tarsi black, clothed with minute black hairs, except inner margins of last four segments, which are clothed with pale hairs; (middle tarsi missing in case of type) hind tarsi blackish brown, clothed with minute black hairs, proximal three-fourths of first segment cinnamon-buff.

Dardanelles, near Chanak, summer 1923, on horse.

Owing to the shape of the first segment of the antenna in the ♀, *H. latebricola*, which cannot be identified with any species hitherto described, occupies a more or less intermediate position between the *italica* and *pluvialis* Groups of Kröber (cf. O. Kröber, Arch. f. Naturgesch., 88. Jahrg., Abt. A, 8. Heft, p. 138, 1922).

Haematopota belligera, sp. n. (fig. 4).

♀. Length (one specimen), 8.8 m.; width of head, 3 mm.; width of front at vertex, 1 mm.; length of wing, 7.6 mm.

Resembling *H. crassicornis*, Wahlbg., but distinguishable in ♀ sex by first segment of antenna being slightly less swollen; by grey, admedian spots being present and clearly defined on second (visible) abdominal segment; by wings having a uniformly mouse-grey ground-colour, and finer markings, and by veins or portions of veins enclosed within rosettes not being darker than remainder of venation.

Head: front slate-olive, lateral margins, a border surrounding each frontal spot, and a narrow median stripe running from border surrounding median frontal spot to vertex paler (light olive-grey); face and jowls greyish-white pollinose, sides

of face punctate as usual, spots merging into a transverse, clove-brown horizontal upper edging to face on each side, but pair of dark spots on central region of face beneath antennae so small as to be scarcely noticeable, at least in case of type; occiput pale olive-grey, clothed like face and jowls on sides below with white hair; front clothed mainly with short, forwardly curving black hair, and with some whitish hairs on vertical region on each side; frontal spots (*cf.* fig. 4, *a*) black, median spot, at least in case of type, triangular, distinct, lateral spots roughly oval, not in contact with eyes; *frontal callus* (*cf.* fig. 4, *a*) shining black, moderately deep and of practically uniform depth from side to side, lower portion of each lateral extremity in contact with corresponding eye; spot in middle line below callus brownish black, large, but not conspicuous; eyes clothed with minute pale hair; proximal segment of *palpi* pale neutral grey, clothed on outer surface and below with white hair, terminal segment moderately swollen at base, pale drab-grey, clothed on outer surface with appressed, glistening, yellowish hairs, interspersed towards lower margin and distal extremity with minute black hairs, with longer white hair on outside at base, and on under surface of expanded portion; first segment of *antennae* (*cf.* fig. 4, *b*), at least

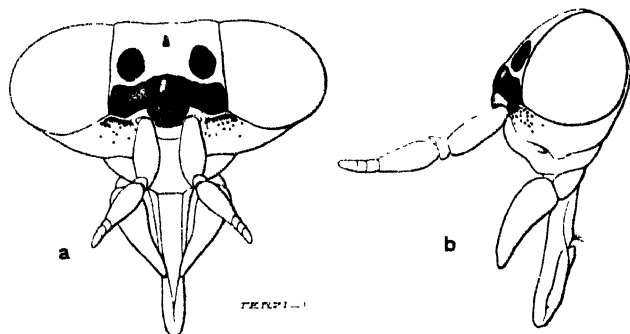


Fig. 4. Head of *Ilacmatopota belligera*, Austen, ♀: *a*, from in front; *b*, in profile. $\times 14$.

in ♀, considerably swollen (more so than in figure), skittle-shaped when viewed from side, about two and a quarter times as long as its greatest depth, with no constriction before its distal extremity, black, rather less than distal half shining, remainder iron-grey pollinose; first segment of antennae clothed above on outer surface and at tip with short black hair, lower surface except at tip with longer white hair; second and third segments of antennae blackish brown or dark clove-brown, second segment clothed with minute black hairs, and with its upper distal angle somewhat produced, third segment with its expanded portion fairly deep, and about half as long again as annulate portion. *Thorax*: dorsum of main portion (scutum) iron-grey, with usual longitudinal markings olive-grey, narrow, but well defined, slender median stripe being continuous from anterior margin to prescutellar groove, posterior halves of outer stripes obliterated with exception of their extremities, lateral borders broadly olive-grey, semicircular mark in front of each basal angle of scutellum also olive-grey and conspicuous; dorsum of scutellum dark olive-grey, with a paler (deep olive-grey) median longitudinal stripe, expanded posteriorly so as to include tip of scutellum; dorsum of thorax including scutellum clothed with short whitish hair, which, on anterior portion of scutum, is interspersed with some erect black hairs; antealar tubercles clothed with longer, outstanding black hair; pleurae and pectus pale neutral grey pollinose, and clothed with white hair. *Abdomen*: dorsum blackish mouse-grey, with sharply defined pale smoke-grey markings, including hind borders of all tergites from second (visible) to sixth inclusive, a median longitudinal stripe extending over same segments and commencing as a narrow triangle, with its apex almost reaching front margin, on second tergite, and a pair of small spots, one on each side of middle line, on each tergite already mentioned; seventh tergite light

greyish olive, with a pair of smoke-grey spots faintly indicated at base ; spots on fourth and following tergites resting on front margin in each case ; lateral extremities of first four tergites pale neutral grey, lateral extremities of following tergites light greyish olive, hind border of first visible tergite pale smoke-grey in centre ; dorsum clothed mainly with short or minute black hair, lateral extremities of tergites, lateral extremities of hind borders of first four tergites, and hind borders of following tergites clothed with longer whitish or silvery-white hair ; venter pale neutral grey pollinose (hind-borders of sternites paler), clothed with short whitish hair, terminal segment with usual median patch of coarse, erect, black hair, three preceding sternites, except hind borders, each somewhat infuscated in centre, and there clothed with dusky hair. *Wings* : all three rosettes developed, though middle and distal rosettes somewhat coalesced, at least in case of type, contiguous borders of proximal and middle rosettes wide apart in discal cell ; pale loop in marginal cell at distal extremity of stigma indistinct ; sinuous mark or transverse streak just before apex of wing distinct, and connected with a series of pale markings along hind border, from distal extremity of first posterior to apex of axillary cell ; *stigma* dark mummy-brown, elongate and sharply defined. *Squamae* smoke-grey, with paler (vinaceous-buff) margins. *Halteres* ivory-yellow, clove-brown just beyond base, knobs with a large, dark clove-brown, basal patch above and below. *Legs* : coxae pale neutral grey pollinose, clothed with whitish hair ; trochanters dark neutral grey ; femora pale neutral grey pollinose and clothed for most part with whitish or silvery-white hair, front femora blackish mouse-grey on inner surface, and having black hairs above and on outer surface on distal half, tips of hind femora also clothed with black hairs ; front tibiae in ♀ in colour and shape, as also in colour and distribution of hairy covering, agreeing closely with those of corresponding sex of *H. frascari*, Austen (*vide supra*), but distal halves perhaps slightly less swollen, *i.e.*, front margin of black portion, when leg is viewed from side, somewhat less convex, and, at least in case of type, no silvery hair on black area ; middle and hind tibiae clove-brown, in each case with two cream-buff bands, which thus give rise to three dark bands, at base, in middle and at distal extremity respectively ; middle tibiae, except distal dark band, which is covered with black hair, clothed with silvery-white hair, except extensor surfaces of basal and middle bands, which bear black hairs ; hairy covering of hind tibiae similar in character, but silvery-white hair more noticeable on anterior than on posterior surface ; front tarsi entirely black, middle and hind tarsi blackish brown, except rather more than proximal half of first segment in each case, which is cream-buff ; all tarsi clothed with minute black hair, tips of segments in case of front pair with some longer brownish hairs.

Dardanelles, near Chanak, summer 1923, on horse.

Genus *Tabanus*, Linn.

Tabanus ater, Rossi.

One ♀, Dardanelles, near Chanak, summer 1923.

This South European species was already well represented in the National Collection by specimens from S. France, Spain, Portugal, Italy, Bosnia and Greece.

Tabanus spectabilis, Lw.

One ♀, Dardanelles, near Chanak, July 1922, "caught in Hospital building ;" one ♀, near Chanak, summer 1923.

For a note on what is known as to the distribution of *T. spectabilis*, see Austen, Bull. Ent. Res., xiii, pt. 3, p. 289 (January 1923). The representatives of this species previously contained in the British Museum (Natural History) consist of : a ♂ from Macedonia, Struma Valley, near Orljak, 27.vii.1916 (*E. E. Austen*) ; two ♀♀

from Bulgaria, Pavel-Bania, near Kazanlik, 10 and 13.viii.1906 (*Prof. Schischkoff*); and a ♀ from Irak, Hinaidi Cantonment, near Baghdad, August 1921 (*Major A. D. Fraser*).

***Tabanus rousselii*, Macq.**

Tabanus rousselii, Macquart, Mém. Soc. roy. des Sc., de l'Agric. et des Arts de Lille, 1838, pt. 3, p. 297 (1838).

Tabanus bifarius, Loew, Verh. z.-b. Ges. Wien, viii, p. 595 (1858). [New synonym.]

Tabanus kervillei, Surcouf, Bull. Soc. des Amis des Sc. nat. de Rouen, (5) xlvii, p. 24 (1912). [New synonym.]

Three ♂♂, three ♀♀, Dardanelles, near Chanak, summer 1922; one ♀, same locality, summer 1923.

As stated by Szilády (Biol. Hung., i, 1, p. 14, 1923), Miss Ricardo (Ann. Mag. Nat. Hist., (7) xvi, p. 197, 1905) was mistaken in regarding *T. rousselii*, Macq., as a synonym of *T. (Ochrops) rusticus*, Linn.; the briefest examination of specimens will suffice to show that the two species have nothing to do with each other. On the other hand, Szilády (*loc. cit.*, p. 15), when pointing out the close relationship, as he considers it, between *T. bifarius*, Lw., and *T. rousselii*, Macq., might well have gone further. A comparison of Major Fraser's specimens with the extensive series of examples hitherto preserved in the British Museum (Natural History) under the designation *T. bifarius*, and also with a number of Algerian specimens determined as belonging to *T. rousselii*, shows beyond doubt that the two names refer to the same species. The relative sizes of the two frontal calli in the ♀ (a detail mentioned by Macquart in his original description, and emphasised by Szilády, *loc. cit.*) entirely depend upon the condition of the specimen as regards rubbing. In one of Major Fraser's examples the upper callus is not visible at all, while in the three other ♀♀ it is well marked, although variable in size; and similar variations are exhibited by the ♀♀ among the European series of specimens, previously standing in the Museum under the label *T. bifarius*, Lw. In his original description of *T. rousselii*, which is based on the ♀, Macquart states that the lateral extremities of the first two abdominal segments are tawny (*fauves*), and this detail, and the alleged smaller size of the upper frontal callus as compared with the lower, are quoted by Szilády (*loc. cit.*) as constituting the only distinctive characters that he is able to mention for *T. rousselii* when contrasted with *T. bifarius*. Szilády adds that among the European specimens examined by him he was unable to find one showing the two (lighter coloured) spots on each side of the abdomen, whereas in examples from North Africa it rarely happens that these spots are absent. However, out of five Algerian ♀♀ of *T. rousselii* in the National Collection, one at least has the lateral extremities of the first two abdominal segments little, if any, paler than the area surrounding the median dorsal longitudinal stripe. On the other hand, out of four ♀♀ of "*T. bifarius*" from Macedonia (*Dr. C. M. Wenyon*), one shows a distinct, pale cinnamon-coloured tinge in the basal angles of the second (visible) abdominal tergite. It may be added that all ♂♂ in the Museum collection, whether from localities in Europe, Algeria or Asia Minor, have the lateral extremities of the second and third (visible) abdominal tergites broadly ochraceous-tawny or ochraceous-buff.

In the wing of *T. rousselii* the anterior branch of the third longitudinal vein generally exhibits a short appendix at the base, though this is sometimes absent. All six of Major Fraser's specimens from the Dardanelles show the appendix; in the case of three cotypes of *T. kervillei*, Surc., from the vicinity of Homs (Syria), kindly presented to the British Museum by Baron J. M. R. Surcouf, the appendix is wanting, except in one instance in which it is present in a somewhat vestigial condition, although more distinct in the right wing than in the left.

The determination of the precise differences between the present species and *T. lunatus*, Fabr., to which the former is undoubtedly nearly allied, is a problem that requires further study.

The series of specimens in the National Collection shows that *T. roussellii* is generally distributed in the Mediterranean Subregion, at least from Algeria through Syria and Asia Minor, to Greece and Italy.

***Tabanus lunatus*, Fabr.**

Four ♀♀, Dardanelles, near Chanak, summer 1922.

Among the localities given by Brauer (Denkschr. k. Akad. Wiss. Wien, xlii, p. 172, 1880) for this South European species are Brusa and Amasia in Asia Minor. The British Museum possesses specimens of *T. lunatus* from Greece, and also from Algeria.

***Tabanus umbrinus*, Meig.**

Three ♂♂, six ♀♀, Dardanelles, near Chanak, summer 1922; one ♀, same locality, summer 1923.

According to Loew (Verh. z.-b. Ges. Wien, viii, p. 609, 1858), this South European species is common in Asia Minor; for records of *T. umbrinus* in Palestine, cf. Austen, Bull. Ent. Res., xiv, p. 426 (May 1924). It may be added that, so far at least as material in the British Museum is concerned, Palestine ♀♀ of the species appear to differ from those occurring at the Dardanelles, as well as from European examples, by the front (frons) being somewhat wider below.

***Tabanus leleani*, Austen.**

Tabanus leleani, Austen, Bull. Ent. Res., x, pt. 3, p. 312, figs. 13, 14 (April 1920); xiii, pt. 3, p. 287 (January 1923); and xiv, pt. 4, p. 430 (May 1924).

Three ♀♀, Dardanelles, near Chanak, summer 1922; six females, same locality, summer 1923.

For the geographical range of this widely distributed species, cf. Austen, Bull. Ent. Res., xiii, loc. cit.

Apud Surcouf (Ann. Soc. Ent. France, xci, p. 238, 1922), in Algeria *T. leleani* has been bred from larvae found in hundreds beneath algae, in from two to four centimetres of water.

***Tabanus fraseri*, sp. n. (fig. 5).**

♀. Length (one specimen), 14 mm.; width of head, 4.6 mm.; width of front at vertex, 0.6 mm.; length of wing, 10.75 mm.

Bare-eyed, smallish, greyish (dorsum of thorax mouse-grey, dorsum of abdomen deep mouse-grey) species, with dorsum of thorax, at least anteriorly, displaying conspicuous paler longitudinal stripes, and that of abdomen bearing, besides a pale and not sharply defined median longitudinal stripe, a double series of pale, clean-cut oblique spots. Wings without an appendix to anterior branch of third longitudinal vein; tibiae pale, cream-buff or pinkish buff (posterior surface of hind pair cinnamon-buff), their distal extremities infuscated, especially in case of front pair.

Head: front in ♀ deep olive-buff pollinose, with two black frontal calli, without a vestige of an ocellar tubercle, but with a deep mouse-grey area shaped somewhat like a blunted isosceles triangle extending forwards from vertex, divided by a paler median line; pollinose area of front clothed with minute, cream-coloured or

yellowish hairs, infuscated area on vertex clothed with minute black hairs; *upper two-thirds of subcallus*, at least in case of type, *shining black*, remainder of subcallus deep olive-buff pollinose, an ill-defined, darker, horizontal mark extending from base of each antenna to inner margin of corresponding eye; face and jowls pale gull-grey pollinose, clothed with whitish hair; occiput pallid neutral grey pollinose, posterior orbits inconspicuous, their hind margins fringed above with short, glistening, olive-buff hair; *front* in ♀ of moderate width, narrowing slightly below, about six times as long as its breadth at lower end; *frontal calli* shaped as shown in fig. 5, *a*; lower frontal callus shining, only narrowly separated from eye on each side, its lower margin well above level of lower, inner angles of eyes and, at least in case of type, indented in middle line, upper margin of lower frontal callus curved; upper frontal callus oblong, at least in case of type, and not connected with lower callus; *eyes* in ♀ sex with three dark purple transverse bands; *palpi* cream-coloured, pale gull-grey pollinose, clothed on outer surface and above with hair similar to that on jowls, and, at least in case of type, entirely devoid of black hairs, distal segment, at least in case of type, remarkably small, fairly broad at base and abruptly acuminate beyond bend in upper margin; first and second segments of *antennae* pinkish buff as to ground-colour and cream-buff pollinose, first segment small, not swollen distally, and with its upper distal angle not embracing second

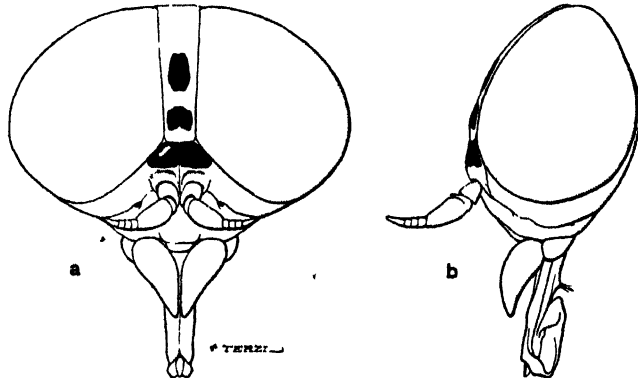


Fig. 5. Head of *Tabanus fraseri*, Austen, ♀; *a*, from in front; *b*, in profile. $\times 10$.

segment, clothed on outer side with short, glistening, pale yellowish hair; second segment of antennae small, but with its upper distal angle strongly produced, and resting on rounded shoulder of third segment, a few minute black hairs on upper portion of distal margin of second segment; expanded portion of third segment of antennae ochraceous-tawny, annulate portion tawny, expanded portion of moderate depth, about one-fourth longer than annulate portion, and with its upper margin, at least in case of type, not excavated but descending almost in a straight line from angle, which, being rounded, close to base and beneath tip of prolongation of upper distal angle of second segment, is scarcely noticeable. *Thorax*: dorsum of main portion (scutum) with fore and lateral borders, and three narrow and clearly defined longitudinal stripes (one median, and one on either side of middle line, midway between median stripe and lateral margin) pale smoke-grey, stripes commencing on fore border, but becoming indistinct after passing transverse suture and before reaching hind margin; dorsum of thorax, including scutellum, except as stated mouse-grey pollinose, clothed with short, appressed, glistening dark olive-buff hair, mingled with short, erect, blackish hair, antealar tubercle on each side and swelling immediately behind it clothed mainly with black hair, lateral borders of scutellum similarly clothed, humeral calli, and lateral border above base of wing on each side, including outer margin of postalar callus, clothed with whitish hair;

pleurae and pectus pallid neutral grey pollinose, clothed with whitish hair. *Abdomen*: hind borders of all tergites, from second (visible) to penultimate inclusive, pale (olive-buff pollinose), second tergite with a similarly coloured edging on fore border on each side of middle line, but not extending to lateral margins; second tergite (at least in case of type) with a faint but distinct ochraceous-tawny tinge, overspread with smoke-grey pollen, broadly occupying each basal angle, a trace of a similar tinge near each basal angle of third tergite also; second and four following tergites each with a blackish or dark mouse-grey transverse mark on each side, in front of pale hind border and on outer side of pale oblique spot, a trace of a continuation of these dark transverse marks on inner side of oblique spots also, at least in case of second to fifth tergites inclusive; each tergite, from first (visible) to seventh inclusive, with a pair of oblique, pale (olive-buff pollinose) spots, situated one on each side of middle line, midway between latter and lateral margin; spots are largest on second (visible) tergite, and most distinct on this and following two tergites, on each of which they are more or less elliptical ovate in outline; on remaining segments they are smaller and less distinct, circular on first and last tergites, and elongate on fifth and sixth, where, like spots on last segment, they are in contact with front margin only; spots on first and third tergites are in contact only with hind margin in each case, those on second and fourth tergites with both front and hind margins, at least in case of type; ill-defined median longitudinal stripe greyish-olive pollinose, extending from base of dorsum at least as far as hind margin of penultimate segment, but interrupted by pale hind borders of tergites, and on third tergite also interrupted by a dark anterior border; lateral extremities of first (visible) tergite, except hind borders which are cream-buff, smoke-grey pollinose, and clothed with erect, whitish hair; dorsum, except lateral margins, hind borders of first five tergites and pale, oblique spots, clothed with short black hair, hind borders of first five tergites and pale oblique spots clothed with short, appressed, glistening cream-coloured hair, similar hairs also present on greyish-olive pollinose median longitudinal stripe, lateral margins of second to sixth tergites inclusive clothed with longer cream-coloured hair, hind border of seventh tergite clothed with longer black hair; venter, except terminal segment, which is dark mouse-grey, and clothed with usual coarse, erect, black hair, drab-grey pollinose and clothed with minute, appressed, cream-coloured hairs, hind margins of first five visible sternites cream-buff, a broad dusky median longitudinal stripe, more conspicuous on penultimate sternite than elsewhere, distinctly visible although not sharply defined. *Wings* uniformly tinged with smoke-grey; veins lighter or darker sepia-coloured; *stigma* but faintly indicated, scarcely noticeable. *Squamae*: membrane colourless, borders cream-buff fringed with glistening whitish hair. *Halteres* pinkish-buff, knobs clove-brown at base above and below. *Legs*: coxae and middle and hind trochanters pallid neutral grey pollinose, clothed with whitish hair, front trochanters cinnamon-brown; front femora above and on posterior surface pallid neutral grey pollinose and clothed with whitish hair, anterior and flexor surfaces shining blackish brown, bare; middle and hind femora pallid neutral grey pollinose, clothed with whitish hair, tips of all femora cinnamon-buff, with a few black hairs above in case of front and middle pairs; tibiae clothed mainly with short, glistening, silvery hair, fringe on anterior edge of extensor surface in case of hind pair composed partly of black, partly of whitish hair, black hairs also present on extensor surfaces of front and middle tibiae; distal fourth of front tibiae brownish black, tips of hind tibiae clove-brown, those of middle pair brownish; front tarsi brownish black, not at all expanded; middle and hind tarsi mummy-brown and clothed mainly with minute black hairs, first segment in each case ochraceous-buff except at tip, and clothed in part with minute, appressed, glistening whitish or yellowish white hairs.

Dardanelles, near Chanak, summer 1922.

The species described above, which is dedicated to its discoverer, shows some affinity to *T. glaucopsis*, Mg., but is distinguishable in the ♀ sex, *inter alia*, by the small size of the basal segment of the antennae and the very small size of the terminal segment of the palpi, and by both being clothed entirely with pale instead of largely with black hair. From the ♀ of *T. lunatus*, Fabr., that of *T. fraseri*, apart from its greyer appearance, and the characters presented by the antennae and palpi, may be distinguished by the eyes being bare, the front usually broader, the posterior margin of the upper portion of the posterior orbits fringed entirely with pale instead of partly with black hair, and by the brownish black area at the tips of the front tibiae being noticeably less deep.

***Tabanus oppugnator*, sp. n. (fig. 6).**

♀. Length (one specimen), 13.75 mm.; width of head, 4.5 mm.; width of front at vertex, 0.6 mm.; length of wing, 11.5 mm.

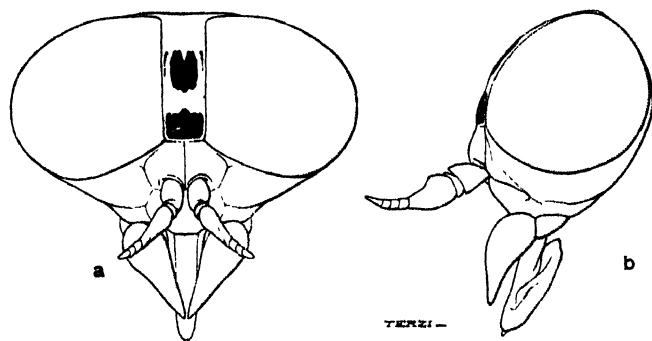


Fig. 6. Head of *Tabanus oppugnator*, Austen, ♀; a, from in front; b, in profile. × 10.

Small, dusky, hairy-eyed species resembling T. nemoralis, Mg., *in general appearance, but, in ♀ sex, at any rate, distinguishable at once, inter alia, by eyes being unbanded and first segment of antennae and distal segment of palpi much more swollen. Dorsum of thorax dark plumbeous, with paler longitudinal stripes; dorsum of abdomen dark neutral grey, with extreme hind margins of segments and two longitudinal series of spots, as also a faintly indicated median longitudinal stripe, pale. Wings without appendix to anterior branch of third longitudinal vein; tibiae ochraceous-buff, infuscated at tips.*

Head: front in ♀ smoke-grey pollinose, with two black frontal calli, with no ocellar tubercle, but with vertex, except lateral and posterior margins, occupied by a somewhat darker (mouse-grey), quadrate area; pollinose area of front clothed mainly with short black hair, except immediately above and below lower frontal callus, where hair is pale yellowish; subcallus, face and jowls pale gull-grey pollinose, face and jowls clothed with whitish hair, no horizontal dark mark between base of each antenna and inner margin of corresponding eye; occiput pallid neutral grey pollinose, clothed below with whitish hair, hind margins of posterior orbits infuscated above, and fringed with unusually long, fine, erect, blackish hair, mingled with, and in region of vertex largely replaced by, fine yellowish hair, which is shorter on each side; front in ♀ moderately broad and of uniform width, about three and a-half times as long as broad; frontal calli shaped as shown in fig. 6, a; lower frontal callus moderately shining, quadrate and separated from eye on each side by an exceedingly narrow interval, its vertical height being only about three-fourths of its transverse diameter; lower margin of lower frontal callus a little above level of lower, inner angles of eyes; upper frontal callus not connected with lower callus, and, at least in case of type, somewhat U-shaped, its upper margin having a narrow indentation

in median line ; eyes in ♀ sex clothed with short, pale hair, and apparently unbanded ; proximal segment of *palpi* agreeing with jowls in colouration and hairy covering, distal segment in ♀ cream-buff, strongly swollen as regards its basal half, then tapering to a point, clothed on outer side with minute, glistening, cream-coloured hairs, sparsely intermingled beyond base with minute black hairs, and clothed on under surface of base with longer, cream-coloured hair ; first segment of *antennae* neutral grey pollinose, strongly swollen distally, with its upper margin convex beyond base, and its blunt upper distal angle enveloping second segment and blackish at tip ; first segment of antennae clothed above on outer surface with minute black hairs, and below with longer whitish hair, on upper surface beyond base bearing a tuft of long blackish hairs projecting forwards at an angle ; blunt upper distal angle of first segment clothed with closely set minute black hairs, inner surface of first segment towards distal angle clothed with minute yellowish hairs ; second segment of antennae short, mummy-brown, neutral grey pollinose on outer surface, clothed below with whitish hair, and on outer distal margin and upper distal angle, which is strongly produced, clothed with minute black hairs ; third segment of antennae black, expanded portion about one-fourth longer than annulate portion, with prominent blunt angle in middle of its upper margin, and with its proximal half rather deep. *Thorax* : dorsum with three light neutral grey longitudinal stripes, commencing on fore border and consisting of a clearly-defined median stripe, which terminates on a level with anterior margin of base of wings, and two somewhat less sharply marked admedian stripes, which reach prescutellar groove, and are somewhat expanded at each extremity ; anterior and lateral borders of dorsum, including humeral calli, light neutral grey pollinose, an additional light neutral grey longitudinal stripe on each side behind transverse suture, running from latter to inner extremity of postalar callus, and there connected with corresponding admedian stripe ; main portion of dorsum (scutum) clothed mainly with fine, erect, blackish hair, scutellum clothed with cream-buff hair ; antealar tubercle on each side drab-grey, clothed with fine black hair ; pleurae and pectus pale smoke-grey pollinose, clothed with whitish hair. *Abdomen* : second (visible) and following tergites, each with a pair of more or less rounded or ovate olive-buff pollinose spots, each spot being midway between median line and lateral margin, or rather nearer latter ; spots not distinctly in contact with either front or hind margins of segments, though nearer latter in case of second and third tergites, large and conspicuous on second tergite, then diminishing successively in size and on last segment very small and inconspicuous ; hind margins of second (visible) and following tergites (scarcely noticeable in case of last tergite) olive-buff, hind margin of first (visible) tergite narrowly and faintly vinaceous-buff, with a small, triangular expansion in middle line ; lateral extremities of first (visible) tergite broadly smoke-grey or pale smoke-grey pollinose, basal angles and lateral extremities of second tergite drab-grey pollinose, lateral margins, including posterior angles, of third and following tergites pinkish-buff ; commencing on hind border of first (visible) tergite, and terminating on hind margin of penultimate segment, a not very conspicuous olive-buff pollinose median stripe, expanded on hind margins of segments and thus consisting of a series of narrow, truncated triangles, with their apices directed forwards ; dorsum clothed on basal angles with whitish hair, on lateral extremities and posterior angles of second and following tergites with Naples yellow hair, and on spots, hind margins and median stripe on second to sixth segments inclusive with short or minute, glistening, Naples yellow or cream-buff hair ; hind margin of first (visible) tergite, as well as an area on each side of same tergite, also clothed with cream-buff hair ; dorsum otherwise clothed mainly with short black hair ; venter pallid neutral grey pollinose, with a median longitudinal blackish stripe, commencing at base of second (visible) sternite, terminating on terminal sternite, and narrowly interrupted by hind margins of second and four following sternites, which are light buff or cream-buff ; first (visible) and base of second sternite clothed with fine, erect whitish hair ; a few

erect black hairs on penultimate sternite in region of median longitudinal stripe; terminal sternite, except hind margin on each side, clothed with usual coarse, erect, black hair; venter otherwise clothed with short, appressed, cream-buff hair (longer on hind margins, including hind margin of terminal sternite on each side). *Wings* hyaline, with a faint, uniform, neutral grey tinge; veins mummy-brown; *stigma* colourless, scarcely noticeable. *Squamae* ivory-yellow, with cream-buff borders fringed with pale hair; borders of antisquamae mummy-brown. *Halteres*: stalks cream-buff, knobs clove-brown. *Legs*: coxae and hind trochanters smoke-grey pollinose, clothed with whitish hair, front and middle trochanters mummy-brown; femora, except extreme tips, which are ochraceous-buff, neutral grey of light neutral grey pollinose and clothed with whitish hair (flexor surface of front pair shining black and bare), extreme tips of all femora with some small black hairs above; distal two-fifths of front tibiae blackish-brown, somewhat greyish pollinose, middle and hind tibiae narrowly banded with clove-brown just before distal extremities, bands on hind tibiae deeper and darker than those on middle pair; tibiae clothed mainly with short, appressed, glistening, pale (ivory-yellow or cream-buff) hair, front tibiae also with a few long, fine, black hairs on extensor surface of their proximal halves, and with some minute black hairs on their blackish-brown tips; middle tibiae with some minute black hairs on extensor surface, at least on proximal halves, and with a series of long, fine, outstanding, cream-buff hairs on posterior margin of middle third of extensor surface; hind tibiae with a conspicuous outer fringe of fine, ivory-yellow hair, with which, at least in case of type, no black hairs are intermixed; front tarsi black, not expanded; middle and hind tarsi blackish-brown, first segment in case of middle pair with its proximal half ochraceous-buff; upper surface of all tarsi clothed with minute black hairs, with which some minute yellowish hairs are intermixed on proximal halves of first segment of middle and hind pairs.

Dardanelles, near Chanak, summer 1923.

In addition to its similarity in facies to *Tabanus nemoralis*, Mg., as noted in the diagnosis printed in italics above, the ♀ of *T. oppugnator*, apart from being much greyer, exhibits a certain resemblance, especially as regards the width of the front and the shape of the lower frontal callus, to that of *T. quatuornotatus*, Mg. Passing over all other characters, however, the former is at once distinguishable from the latter by the vertex and subcallus being pollinose, and the wings practically colourless and devoid of a stigma.

Family MUSCIDAE.

Subfamily STOMOXYDINAE.

Genus *Stomoxys*, Geoff.

Stomoxys calcitrans, Linn.

One ♀, Dardanelles, near Chanak, summer 1922, two ♀♀, same locality, summer 1923, "on horse."

Genus *Lyperosia*, Rond.

Lyperosia irritans, Linn.

Three ♂♂, seven ♀♀, Dardanelles, near Chanak, summer 1923, "on horse."

Lyperosia titillans, Bezzi.

Lyperosia titillans, Bezzi, Rend. R. Ist. Lomb. Sc. Lett., (2) xl, pp. 454-455 (1907).

Nine ♂♂, three ♀♀, Dardanelles, near Chanak, summer 1923, "on horse."

Of this South European species the Museum previously possessed a ♂ cotype from Italy, Sondrio, 16.vi.1904 (*Prof. M. Bezzi*), and a second specimen of the same sex from Crete, near Kanea (*Miss D. M. A. Bate*).

Family HIPPOBOSCIDAE.

Genus **Hippobosca**, Linn.**Hippobosca equina**, Linn.

One ♀, Dardanelles, near Chanak, summer 1923, "on horse."

Genus **Lipoptena**, Nitzsch.**Lipoptena caprina**, Austen.

Lipoptena caprina, Austen, Bull. Ent. Res., xii, p. 122 (September 1921); Trans. R. Soc. Trop. Med. Hyg., xv, p. 264 (May 1922).

One ♂, Dardanelles, near Chanak, summer 1923, "on a dog, fairly common."

This interesting little species was described by the writer from a series of individuals of both sexes, taken by him near Jerusalem, in June and July 1918, on goats and kids. In none of the specimens belonging to the original series are the wings represented by more than stumps, though the latter exhibit considerable variation in size. Subsequently, however, the British Museum received from Dr. P. A. Buxton a fully winged ♂, taken by the donor at Nazareth, Galilee, 22.v.1922, on a horse's withers; and wings in perfect condition are also present in the case of Major Fraser's specimen from the Dardanelles, recorded above. As compared with the wings of the genotype, *Lipoptena cervi*, Linn., those of *L. caprina* are much paler, being perfectly hyaline; the principal veins are less strongly chitinised, and the third longitudinal vein joins the costa at a sharper angle.

Apart from Dr. Buxton's and Major Fraser's specimens already mentioned, further material as specified below, belonging to *L. caprina*, has been added to the National Collection since the species was described: two ♂♂, Jerusalem, 5.vii.1922, on goat (*Dr. P. A. Buxton*); a series of specimens of both sexes from goats and camels, with the addition of a single ♀ from a cow, Jerusalem, 3, 4.ix.1922 (*M. Sidky*: presented by the Imperial Bureau of Entomology); four ♂♂, India, Punjab, Jhelum district, 19, 21.xi.1922, on goat (*Captain H. E. Cross*). (Cf. also Austen, Trans. R. Soc. Trop. Med. Hyg., *loc. cit.*)

THE INTERNAL ANATOMY OF THE CLOVER ROOT MEALY-BUG,
TRIONYMUS TRIFOLII, FORBES (HOMOPTERA, COCCIDAE).*

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The purpose of this paper is to present the more important features of the internal anatomy of a subterranean viviparous mealy-bug commonly found on the roots of clover in the eastern part of the United States. Only the female was studied, since the male has never been found. No attempt was made to present many of the details which were found to resemble homologous parts of the common oviparous mealy-bug, *Pseudococcus citri*, Risso, as described by Berlese in 1893.

Previous observations made by the writer (1922) at Columbus, Ohio, revealed the fact that this mealy-bug passes the winter as an adult in the nests of the brown garden ant (*Lasius niger*, Linn., var. *americanus*, Emery). During the growing season the Coccids are carried about by the ants and placed on the roots of clover and on those of several other plants. From the anal opening they produce honey-dew very profusely, on which the ants feed, and in return for this much-prized food the ants reciprocate by caring for the mealy-bugs through all seasons of the year.

Methods.

Specimens were killed in warm water (70° C.), placed in Carl's fixing fluid overnight, dehydrated in the usual alcohols, embedded in paraffin, sectioned (5 to 25 microns), stained in Delafield's hematoxylin and eosin, cleared in xylol and mounted in Canada balsam. The celloidin method of infiltration and embedding was also used, but was not found superior to the shorter paraffin method as outlined.

In studying the cellular structure of the rectum and pseudovitellus and the anatomy of the mouth region a 10× eye-piece and an oil immersion lens (1.8 mm.) were used. Figures 2, 3 and 6 were made from a 10× eye-piece, and 4 mm. and 16 mm. lenses.

In life the adult females averaged 2 mm. in length.

Respiratory System (figs. 2 and 6).

The four principal trunks open on the ventral side of the body on the second and fourth segments. Each trunk breaks into a number of branches just inside of its spiracle, and these divide into many branches. There is a conspicuous network of very minute tracheae just above the brain. The pseudovitellus is very liberally supplied with tracheae from the trunks of the fourth segment.

Reproductive System (figs. 2 and 6).

The Y-shaped reproductive system of the female is not unlike that of other scale-insects. The tube-like ovaries with many eggs in various stages of development unite to form the oviduct. The spermatheca opens into the oviduct near its external

* Contribution from the Department of Zoology and Entomology, Ohio State University, Columbus, Ohio, U.S.A. Paper number 81.

opening. A pair of small genital glands are found one on each side of the oviduct near its external opening. The fact that the spermatheca is well developed indicates that this insect is not parthenogenetic, as the writer was inclined to believe from previous observations on its life-history. Since all of the material for study was collected from clover roots late in October and November no young were found in any of the females. All of the individuals examined were either in the last larval instar or early adult stage.

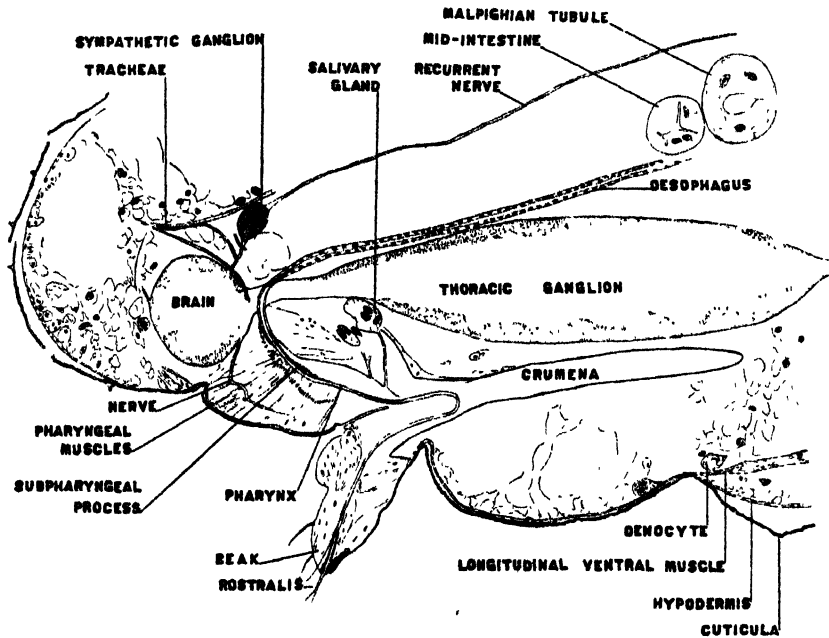


Fig. 1. Sagittal section of head region.

Nervous System (figs. 1, 2 and 6).

The brain (superoesophageal ganglion) and the large thoracic (suboesophageal) ganglion are connected by a large commissure through which the oesophagus passes. From the brain come the nerves of the antennae, eyes, mouth and sympathetic system. In a sagittal section the oesophageal sympathetic system appears as shown in fig. 2. No frontal ganglion was found, but a minute nerve connects the brain with a large sympathetic ganglion lying above it. From this large ganglion a conspicuous recurrent nerve leads backward to the visceral ganglion. Two visceral or stomatogastric nerves pass from this ganglion into the visceral region.

The nerves of the thoracic ganglion are the three pairs of nerves which supply the abdominal region, pseudovitellus and reproductive organs respectively.

Digestive System (figs. 1, 2, 3, 4 and 6).

The mouth-parts are not essentially different from those of other Coccids. The salivary ducts branch a number of times, and at the distal end of each branch is a pyriform gland with two or three large nuclei. The glands appear as a bunch of pear-shaped bodies lying on each side of the oesophageal commissure and apparently are fully developed. For the most part the salivary glands lie above the oesophageal commissure, although the branching begins at a short distance from the pharynx.

The delicate-walled oesophagus is recognised by its conspicuously nucleated cells. At its posterior end it enters the anterior end of the rectum and suddenly widens into the stomach or mid-intestine. A ring of elongated cells form the oesophageal valve. The stomach coils on itself, then passes out of the rectum at its anterior end just below and near where the oesophagus enters. After making a large loop over the pseudovitellus it returns to the region of its origin, where the beginning of the hind intestine is marked by the entrance of the malpighian tubules.

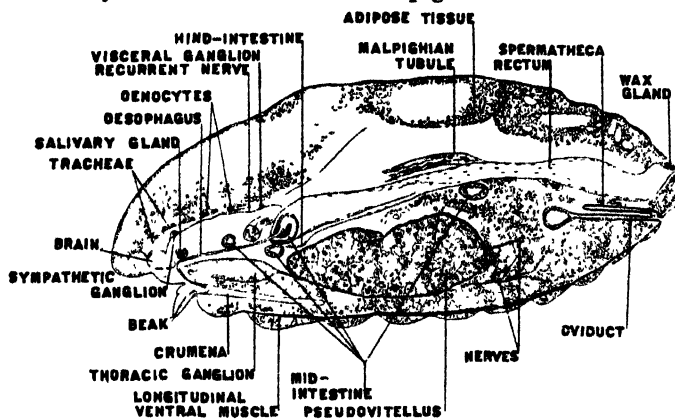


Fig. 2. Sagittal section of adult ♀.

The hind-intestine is very peculiar, being suddenly constricted into a narrow tube or intestinal duct beneath the anterior end of the rectum. This duct follows along beneath the rectum for about one-third of the length of the latter before entering it. Except at its anterior end the cellular structure of the duct is more like that of the rectum than that of the intestine.

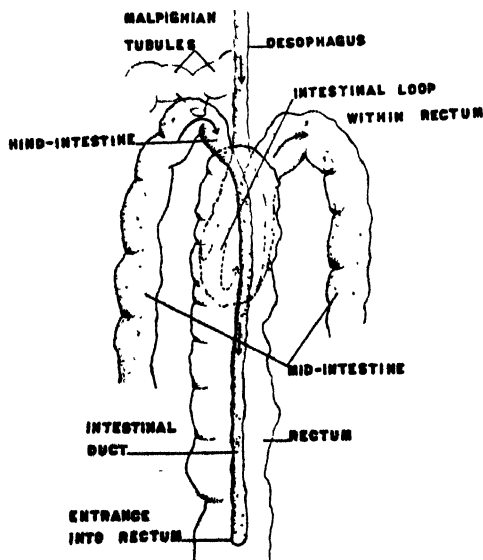


Fig. 3. Intestinal loop, ventral view.

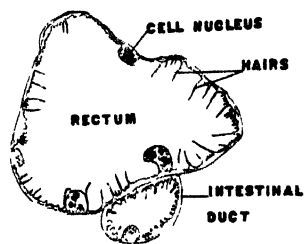


Fig. 4. Cross-section of rectum and intestinal duct.

The rectum is a long dilated tube extending for fully three-fourths of the body length. The clear thin walls are characterized by long narrow nuclei, which on cross section appear as dark-stained prominences extending into the lumen of the

tube. There are many hair-like growths distributed over the inner wall throughout the entire length of the rectum. The writer is inclined to believe that the rectum so-called is in reality the large intestine; at least it is certainly not comparable with the true rectum of most insects.

The Malpighian Tubules (figs. 1, 2, 3 and 6).

These are easily recognised by their large granular cells with large nuclei. Just before entering the intestine they unite to form a single tube. Their distal ends are free.

Muscle System (figs. 1 and 2).

On the ventral floor are numerous strands of longitudinal muscle fibres. Between the second pair of legs is the conspicuous thoracic furca to which these muscles are attached and from which they extend anteriorly and posteriorly. Beneath the dorsal wall, and somewhat to the right and left of the median plane, are the strands of the longitudinal dorsal muscles which extend throughout the length of the body. In each segment there are four sets of vertical muscles anchored to the dorsal and ventral walls. Muscles hold the viscera and pseudovitellus in place.

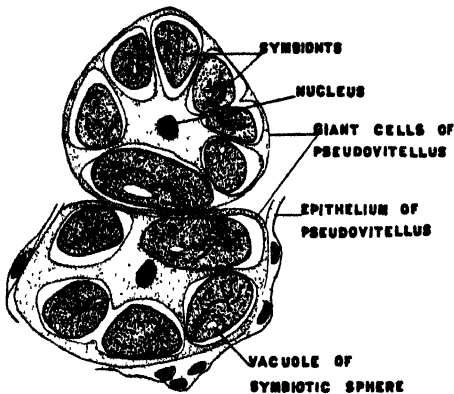


Fig. 5. Two giant cells of the pseudovitellus.

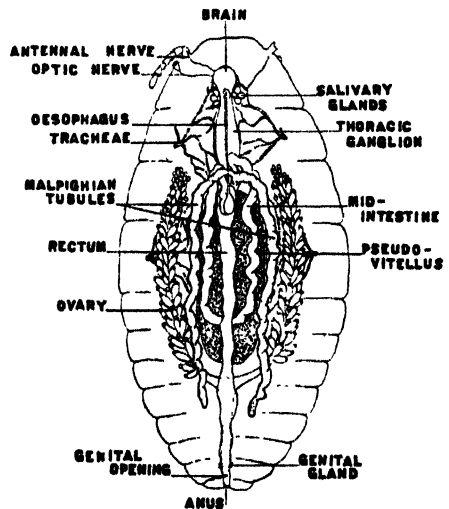


Fig. 6. Internal organs of adult ♀, dorsal view.

The pseudovitellus is second only to the ovaries in being the most conspicuous organ in the body of the adult female. In *Pseudococcus citri* it has been called "corpo ovale" by Berlese (1893) and Pierantoni (1913), and "pseudovitellus" by Buchner (1912). This body does not seem to have any connection with the digestive tract or the ovaries, although the mid-intestine passes over it and the ovaries lie slightly above and on each side. The entire body is made up of large cells which Shrader (1923) calls "giant cells." A very thin epithelium surrounds it. Enclosed in the giant cells are the spheres of symbionts. Each sphere probably contains numerous rod-like organisms or symbionts, but since no special stain was used, only relatively few were observed distinctly from end to end. For the most part the contents of each sphere blurred into an incoherent mass.

Shrader studied the origin of the giant cells in *Pseudococcus citri* and showed that these remarkable cells arise from the fusion of the first and second polar bodies. The polar nucleus then undergoes mitotic divisions forming the large cells called giant cells. Furthermore, he shows that these cells contain thirty or more chromosomes, while all other cells of the embryo contain ten chromosomes. After being pushed in from the periphery of the egg by the growth of the blastoderm the giant cells migrate from the posterior pole toward the anterior end (point of attachment to nurse cells) and surround the spheres of symbionts. According to Shinji (1919), the symbionts of *Pseudococcus citri* enter the egg through the nurse cells at the anterior end. Thus the pseudovitellus or oval body forms early in the embryonic life of the mealy-bug. Both Shrader and Pierantoni have shown that the giant cells are left behind when the spheres of symbionts are transferred to the eggs. I have not been able to find any connection between the pseudovitellus and the ovaries, and am unable to say how the symbionts get into the nurse cells. Perhaps they migrate to the latter through the blood. The ovaries pass just above and on each side of the pseudovitellus and in places actually touch it.

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SUPPLEMENT TO A MONOGRAPH OF THE LACCIFERIDAE (TACHARDIINAE) OR LAC INSECTS (HOMOPT., COCCIDAE).

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Since the appearance in the pages of this Journal in 1923 of the monograph above alluded to,* there has come to the attention of the author certain nomenclatorial changes, errors, additions and criticisms which seem to justify treatment in a supplementary fashion.

In particular, a recent paper purporting to present a classification of the lac insects from a physiological standpoint by S. Mahdihassan, of Bangalore, India,† merits adverse attention as an example of almost everything a scientific treatise should not be. From this I have endeavoured to segregate the names of the species proposed and to gather such slight evidence as to their probable synonymy as is possible. It is unfortunate, but true, that every one of the species therein proposed has enough "descriptive" matter attached (if the treatise be searched thoroughly enough to disclose it) to make it of potential validity. Hence any future systematic work on the commercial lac insects of India must, according to the rules of nomenclature, consider these names. It is one of the regrettable features of our present nomenclatorial rules that such a work as this cannot be ignored.

To attempt anything like a complete criticism of this treatise would involve a paper as large as the original, and to correct all the errors and misapprehensions under which its author laboured would scarcely be more practicable.

I may be somewhat unjust in thus condemning this whole work, but even aside from the strictly "systematic part," and relative to the "physiological" findings, there is little to be said for the soundness of its author's judgment. For example, when he consistently makes such statements as some of those which are given below (and those, too, without the support of any systematically presented, confirmatory data and observations), we cannot but suspect the validity of the whole work. The "systematic methods" of its author are also characteristically displayed in the following verbatim quotation (Mahdihassan, *op. c.* p. 30) :—

"Next to size and colour, the most obvious difference between the insects on *Pongamia glabra* and *Ixora parviflora* is with regard to the symbiotic organisms. As a bacteriological test is superior to a clinical examination, the easiest method of deciding which is the young insect of *Pongamia* and which is the adult insect of *Ixora* is to observe the blood smears of both under a microscope. *The presence of chains of bacteria will prove that the insect was derived from the torch-tree.* (Italics are mine.) In the case of *T. minuta* we do find some cocci-like organisms, but since they have not been cultured, it is impossible to say if these bodies are micro-organisms or granular substances of the insect blood. Yeasts and chains of bacteria are similarly absent from the Travancore insect. From the information given so far, it is possible to identify the insect on *Ixora parviflora* and, as it is new to science, I intend associating with it the name of the great authority on scale insects and insect parasites, I mean Professor Silvestri. I feel this is an humble way of recognising the help and suggestions he has been giving me from time to time. *Tachardia silvestri* is not the only insect which has been described without going into anatomical

* J. C. Chamberlin, 1923—"A Monograph of the Tachardiinae or Lac Insects." Bull. Ent. Res. xiv, pp. 147-212.

† S. Mahdihassan, 1923—"Classification of Lac Insects from a Physiological Stand-point." Jl. Sci. Assoc. Maharaj. Coll., Vizianagaram, i, nos. 2 & 3, pp. 47-99.

details. In their monograph on Indiana scale insects, Morrison and Dietz mention that the Kermes insects apparently show only a broad difference in the shape of tests and their classification is not based on anatomical details."

After reading 53 such pages, which is the extent of this treatise, it is difficult not to feel strongly reminiscent of the chaotic sensations experienced during a similar perusal of certain current pseudospiritualistic doctrines and sublogic, which Jordan has aptly styled Sciosophy.

Had Mahdihassan restrained his pointless divagations and supported his illogically presented *assertions* and observations with actual scientific data, and, furthermore, condensed his treatise by four-fifths, the balance of his observations and conclusions which *do* possess some merit (although in some of these cases, even, he claims an originality not validly his) would have been of some real value.

Thus we must, in all fairness, point out that he did correctly discriminate between the two subfamilies, Lacciferinae ("the true lac insects") and the Tachardiinae ("the pseudolac insects"), on the basis of differences in the physical and chemical qualities of the lac. Similarly, it appears that some, at least, of his ecological observations are of real value.

All further comments, changes and additions are made in their appropriate position in the following systematic section.

I am indebted to Professor T. D. A. Cockerell and Mr. E. E. Green for kindly calling my attention to certain errors, and likewise for considerable additional information.

SYSTEMATIC TREATMENT.

Superfamily COCCIDOIDEA, Ferris.

1923. Ferris, Bull. Ent. Res., xiv, p. 163.

1924. Cockerell, Psyche, xxxi, p. 47.

Ferris, in the statement referred to above, elevated the Coccidac to superfamily rank, a decision in which Cockerell later concurred.

Family LACCIFERIDAE, Cockerell.

1923. *Tachardiinae*, Chamberlin, Bull. Ent. Res., xiv, (2), p. 161.

1923. *Tachardiidae*, Ferris, Bull. Ent. Res., xiv, (2), p. 163.

1924. *Lacciferidae*, Cockerell, Psyche, xxxi, (1), p. 47.

As shown by Cockerell, *Coccus lacca*, the type of the genus *Tachardia* was used by Oken long before in establishing his genus *Laccifer*, and hence the latter name takes precedence, necessitating the change indicated above. This action must be taken according to the international rules of nomenclature, although heartily deplored in this case.

Subfamily LACCIFERINAE, nov.

1923. *Tachardiini*, Chamberlin, Bull. Ent. Res., xiv, p. 163.

As indicated by the preceding elevations in rank, it appears that the only reasonable course to follow is to raise the "tribes" previously recognized to subfamily rank. Certainly, if the first two elevations are justified (COCCIDAE to COCCIDOIDEA and TACHARDIINAE to LACCIFERIDAE), which the author believes to be the case, all lower divisions should also be correspondingly elevated, at least if we regard generic and other groups as purely relative, and not absolute, categories.

The former position is the one to which the author personally adheres, and, consequently, all minor subdivisions are here raised one degree in rank to correspond to the primary changes above indicated.

Tribe LACCIFERINI, nov.

1923. "Suprageneric group of *Tachardiella*" (Shallow Crater Group), Chamberlin, Bull. Ent. Res., xiv, p. 164.

With the diagnosis given under the above citation.

Subtribe LACCIFERI, nov.

Equivalent to the genus *Tachardia* as previously recognised. It includes *Laccifer* and *Metatachardia*.

Genus **Laccifer**, Oken.

1815. *Laccifer*, Oken, Lehrb. Naturg., iii, pt. 1, p. 430.

1874. *Carteria*, Signoret, Ann. Soc. Ent. Fr. (5) iv, p. 101.

1886. *Tachardia*, Blanchard, Zoologie Medicale, p. 1.

1923. *Tachardia*, Chamberlin, Bull. Ent. Res., xiv, p. 164.

1923. *Lakshadia*, Mahdihassan, Jl. Sci. Assoc. Mahraj. Coll. Vizianagaram, i, pp. 41, 43.

1924. *Laccifer*, Cockerell, Psyche, xxxi, p. 47.

As conclusively shown by Cockerell, *Tachardia* must yield precedence to the name *Laccifer*, which with little doubt was the first scientific designation for the lac insects. It even precedes the old and preoccupied genus *Carteria*. I quote from Cockerell:—

"He [Oken] proposes a genus *Laccifer*, for *Chermes* or *Coccus lacca*. It is stated to be the source of gum-lac and to occur by the Ganges on *Mimosa cinerea* and *M. glauca*, plants now known as *Dichrostachys cinerea* (L.) Wight & Arn., and *Leucaena glauca* (L.) Benth. The old error of taking the male Coccid for the adult female and some hymenopterous parasite for the adult male is repeated, but does not invalidate the name."

With the addition of the two new species here proposed the key to the genus may be extended as follows:—

1. Supra-anal plate (anal tubercle) large and elongate, being always a little longer than greatest width 2
Supra-anal plate more abbreviated, being always a little broader than greatest length 3
2. Brachial plates borne upon distinct and elongate brachia... .. *lacca* (Kerr)
Brachial plates sessile, with no trace of brachia *ebrachiata* (Chamberlin)
3. Brachial crater subcircular or subquadrate, not at all longer than broad; ducts of marginal cluster 40-50 or more in number, and ranged in a more or less distinctly convoluted band 4
Brachial crater subrectangular in outline, distinctly longer than broad; ducts of marginal cluster 10-15 in number and borne upon a distinctly chitinous plate *albizziae* (Green)
4. Brachial plate and supra-anal plate sub-equal in area; mouth-parts clusters of star pores absent *fici* (Green)
Brachial plate with one-third or less area than supra-anal plate; mouth-parts clusters of star pores always present 5
5. Marginal duct clusters of distinct duplex type, larger nuclear ducts present *greeni* (Chamberlin)
Marginal duct clusters of simplex-type, no larger nuclear ducts present ... 6

6. Brachia distinctly present although short; crater not well defined; dimples strongly marked (fig. 1, *h*) *rangoonensis*, sp. nov.
 Brachial plates practically sessile, brachia in any case scarcely or not at all visible in prepared material; crater well defined; dimples "weakly" depressed (fig. 1, *j*) 7
7. Marginal duct clusters borne upon a weakly marked oval chitinous plate; perivaginal pore clusters 35-36, tending to form larger secondary clusters *meridionalis* (Chamberlin)
- Marginal duct clusters, not borne upon such a chitinous plate; perivaginal pore clusters 21-23, not secondarily clustered *javanus*, sp. nov.

Group of *L. albizziae* (Green).

Laccifer albizziae (Green).

1903. *Tachardia albizziae*, Green, Ind. Mus. Notes v, p. 198.
 1923. *Tachardia albizziae*, Green, Chamberlin, Bull. Ent. Res. xiv, p. 166.
 1923. *Lakshadia albizziae* (Green), Mahdihassan, Jl. Sci. Assoc. Maharaj. Coll. Vizianagaram, i, pp. 53, 4.
 1924. *Laccifer albizziae* (Green), Cockerell, Psyche, xxxi, p. 47.

Group of *L. greeni* (Chamberlin).

This group is characterised by the invariable presence of the interesting mouth-parts clusters of star pores, and by the possession of a supra-anal plate distinctly broader than long. As understood here, it is a segregate of the "group of *T. fici*" as recognised in my monograph (p. 167). The affinities of the four included species relative to the phylogenetic chart previously given (Bull. Ent. Res., xiv, p. 160, fig. 2) would be as follows: The common stem would arise, as is there indicated, from its union with *fici*; it would almost immediately divide, giving rise to *greeni* and *rangoonensis* on the one hand, and *meridionalis* and *javanus* on the other.

Laccifer meridionalis (Chamberlin).

1923. *Tachardia meridionalis*, Chamberlin, Bull. Ent. Res., xiv, p. 167.
 1924. *Laccifer meridionalis* (Chamberlin), Cockerell, Psyche, xxxi, p. 47.

Remarks.—This species is most closely related to *L. javanus*, sp. nov.

Laccifer javanus, sp. nov. (fig. 1, *a, e, f, g, i, j*).

Type Host and Locality.—"Buitenzorg, Java, on *Ficus* sp., collected by A. Zimmerman." I am indebted to Mr. Green for the loan of this material.

Habit.—Unknown.

Morphology.—Antenna minute, apparently single-segmented, tipped by four long and two short setae (fig. 1, *a*); brachial plates sessile or practically so, with five ill-defined dimples, the crater almost circular, evenly and sharply margined (fig. 1, *j*); anterior spiracles distinctly smaller than brachial plate, although as long as diameter of the latter (fig. 1, *i*), with 45-50 pores; posterior spiracles distinctly anterior to anterior spiracles, typical in appearance, with about 35-40 pores (fig. 1, *f*); dorsal spine typical, slender, as long as width of brachial plate (fig. 1, *g*); the ducts of the dorsal spine of simple, scarcely branched type (fig. 1, *g*); perivaginal pore clusters, small and comparatively few, numbering about 21-23, not secondarily clustered; marginal duct clusters displaced much as in *lacca*, each consisting of about 48-55 ducts of uniform size, ranged in a distinct, convoluted band (fig. 1, *e*);

ventral ducts as in *lacca* forming a loose cluster near the mouth-parts, consisting of 100 or more small, indistinctly visible ducts; mouth-parts duct cluster of 6 or 7 star pores, present as in *greeni*, *rangoonensis* and *meridionalis*; supra-anal plate typical, distinctly, but not prominently, terminally hispid, with a ventral group of fairly prominent setae; anal fringe typical. Length, 3 mm.

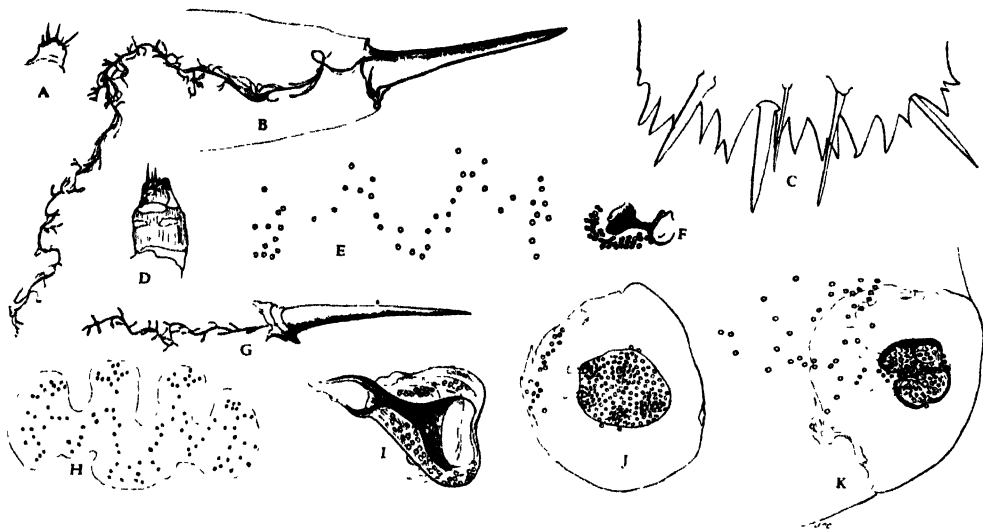


Fig. 1. *Laccifer javanus*, sp. n.: A, antenna; E, marginal duct cluster (higher magnification than fig H); F, posterior spiracle; G, dorsal spine and ducts; I, anterior spiracle; J, brachial plate (same magnification as F and J).

Laccifer rangoonensis, sp. n.: B, dorsal spine and ducts; C, termino-ventral aspect of left half of anal fringe; D, antenna; H, marginal duct cluster (lower magnification than fig. E); K, brachial plate.

(Homologous structures are of same magnification unless otherwise noted.)

Remarks.—This species, no doubt, is most closely related to *meridionalis*, as might be inferred from the geographical distribution of the species of this group. The morphological similarities are most apparent in the brachial plate, dorsal spine and marginal duct clusters.

***Laccifer greeni* (Chamberlin).**

1923. *Tachardia greeni*, Chamberlin, Bull. Ent. Res., xiv, p. 168.

1924. *Laccifer greeni*, Chamberlin, Cockerell, Psyche, xxxi, p. 47.

***Laccifer rangoonensis*, sp. nov. (fig. 1, b, c, d, h, k).**

Type Host and Locality.—"From *Quisqualis*, Rangoon, India, collected by J. H. Burkill." I am indebted to Mr. E. E. Green for the loan of this material.

Habit.—Test very characteristic, in appearance being almost globular, and from a vertical aspect roughly hexagonal in form; the equatorial diameter greatest; with a distinctly depressed apex. Lac light reddish orange in colour. This description was drawn up from notes and sketches kindly supplied by Mr. Green.

Morphology.—Antennae relatively prominent, retaining traces of the segmented condition (fig. 1, d); brachia much as in typical *greeni*, rather short and weakly chitinised; brachial plate small, crater fairly definite and with four distinct dimples

as in *greeni* (fig. 1, *h*); posterior spiracles as in *greeni*; anterior spiracles scarcely posterior to posterior pair, almost even therewith; anterior spiracles large and not chitinously bridged to the brachial plate, subequal in size thereto and their own length therefrom; dorsal spine typical in shape and size (fig. 1, *b*), as long as width of brachial plate; dorsal spine ducts very similar in general structure to those of *greeni*, differing, however, in their relatively finer and more abundant branching; perivaginal pore clusters numbering about 68-70, non-uniform in size, more or less distinctly secondarily clustered; marginal duct clusters prominent, consisting of a more or less convoluted row of 105-115 similar ducts borne upon a similar slightly chitinous plate (fig. 1, *h*), no enlarged nuclear ducts as in *greeni*; ventral ducts ventral and opposite each of the regularly placed marginal clusters and apparently forming in each case a loose and rather indefinite or obscure cluster of 50-60 ducts; mouth-parts clusters, of 25-21 star pores, present as in *greeni*, *javanus* and *meridionalis*; supra-anal plate typical, distinctly hispid, and with a ventral group of fairly prominent setae; anal fringe slightly more lobed than in *greeni*, but otherwise typical (fig. 1, *c*). Length, 2 mm.

Remarks.—This species lies between *greeni*, on the one hand, and *meridionalis* and *javanus* on the other. It is presumably somewhat closer to the former species, although the absence of duplex marginal clusters might be taken as indicating its nearer affinities with the latter two. On the whole, however, it has much more in common with *greeni*, and I am personally inclined to place it nearer thereto, a decision also in keeping with the geographical distribution of the species involved.

Group of *L. fici* (Green).

With the segregation of the "group of *L. greeni*," this group retains but a single species, *L. fici*, characterised by the absence of the mouth-parts star pore clusters, and by the possession of a supra-anal plate, which is distinctly broader than long. This latter feature is also characteristic of the former group. As a whole, of course, the two groups are very closely related.

Laccifer fici (Green).

- 1923. *Tachardia fici*, Green, Chamberlin, Bull. Ent. Res., xiv, p. 168.
- 1923. *Lakshadia* or *Tachardia ficii* (Green), Mahdihassan, Jl. Sci. Assoc. Maharaj. Coll. Vizianagaram, i, pp. 53, 14.
- 1924. *Laccifer fici* (Green), Cockerell, Psyche, xxxi, p. 47.

Group of *L. lacca* (Kerr).

Laccifer ebrachiata (Chamberlin).

- 1923. *Tachardia ebrachiata*, Chamberlin, Bull. Ent. Res., xiv, p. 170.

Additional record.—Through the kindness of Mr. Green, I have had the opportunity of examining a lot of material from Bangalore, India, on *Ficus elastica*.

Supplementary morphological notes.—The number of perivaginal pore clusters is 20-22. The type material indicated 7-8 as to number of dimples, the present material 6-7. The number of marginal ducts per cluster is slightly greater than in the type material, numbering 36-42 instead of "about 35." Otherwise the material is completely typical.

Laccifer lacca (Kerr).

1782. *Coccus lacca*, Kerr, Philos. Trans. lxxi, p. 374.
 1815. *Laccifer lacca* (Kerr), Oken, Lehrb. Naturg., iii, pt. 1, p. 430.
 1874. *Carteria lacca* (Kerr), Signoret, Ann. Soc. Ent. Fr. (5) iv, p. 102.
 1886. *Tachardia lacca* (Kerr), Blanchard, Zoologie Medicale, p. 1.
 1923. *Lakshadia indica*, Mahdihassan, Jl. Sci. Assoc. Maharaj. Coll. Vizianagaram, i, p. 14, lines 9-17, and p. 52, line 10.
 1923. *Tachardia lacca* (Kerr), Chamberlin, Bull. Ent. Res. xiv, p. 170.
 1924. *Laccifer lacca* (Kerr), Cockerell, Psyche, xxxi, p. 47.

Remarks.—The above references give a synoptical review of the generic name changes involved in this group.

Lakshadia indica, Mahdihassan, is no doubt a synonym of true *lacca*. *Butea frondosa*, which is mentioned as its host, is one of the commonest hosts of real *lacca*, and, in addition, Mahdihassan (p. 52, line 10) says: "Inasmuch as there are more pseudolac insects [corresponding to the genus *Tachardina*], I propose retaining for them the old name of *Tachardia*, and for lac insects proper I suggest the more connotative word, *Lakshadia*, derived from the Sanskrit word, *Laksha*. *Tachardia lacca* on *Butea frondosa*, therefore, becomes *Lakshadia indica*." Verily a gem of true logic!

Other of Mahdihassan's so-called species that are possibly or probably synonyms of *lacca*, and which are noted immediately following under the heading "Undetermined and Questionable Species," are *Lakshadia nagoliensis*, *L. sindica* and *L. mysorensis*.

As has been previously pointed out, it is quite possible, and indeed probable, that *lacca*, with further study of abundant and fresh material, will be found to split up into a number of local races or subspecies.

*Undetermined and Questionable Species.***Laccifer nagoliensis** (Mahdihassan).

1923. *Lakshadia nagoliensis* (" *S. trijuga* lac "), Mahdihassan, Jl. Sci. Assoc. Maharaj. Coll. Vizianagaram, i, p. 52, lines 10-15; p. 15, lines 2-15; p. 46, lines 19-25; p. 42, line 34; p. 25, line 15.

Host-plants.—Recorded as attacking *Schleichera trijuga*. This is one of the common hosts of true *lacca*, and hence it seems probable that this is no more than a synonym.

Notes.—The following quotations include the only points of systematic value (?) noted by Mahdihassan.

"The longest stigmatic processes are found . . . nearly as long as anal process."
 "The spinoid process has a broad diameter and the helmet [basal?] portion is very thickly chitinised. Long projections at the caudal end mean more material to fill the space between them. I presume, therefore, that the ether-soluble constituent would be highest in the case of Nagoli lac, as *S. trijuga* lac is commercially called" (p. 46). "This insect exudes a thick layer of resin . . . likely to be mistaken only . . . with the lemon-yellow resin of *L. indica* [= *L. lacca*]" (p. 52).

Laccifer sindica (Mahdihassan).

1923. *Lakshadia sindica* (" *Sind lac* "), Jl. Sci. Assoc. Maharaj. Coll. Vizianagaram, i, p. 52, lines 17-18.

Host.—Apparently no host is listed.

Notes.—The only allusion its author makes to this form is as follows: "Sind lac is much more yellow [than Kusam or Nagoli lac] and its insect should be called *Lakshadia sindica*." He luckily does not give a scientific designation to the insect referred to as "Kusam lac."

***Laccifer mysorensis* (Mahdihassan).**

1923. *Lakshadia mysorensis* ("Mysore lac insect and *Shorea talura* insect), Mahdihassan, Jl. Sci. Assoc. Maharaj. Coll. Vizianagaram, i, p. 52, lines 23-25; p. 1, lines 1-6 and 19-22; p. 2, lines 1-4; p. 13, lines 1-3; p. 14, lines 25-36; p. 15, lines 23-24; p. 17, lines 11-24; pp. 18, 19, 20, 21, 22, 23, 24, and various other places.

Host.—*Shorea talura*. "In spite of very vigorous search the lac insect on *Shorea talura* has never been found on any but its most favourite host . . . After vigorous experimentation in inoculations I find brood lac from *Shorea talura* grows very well on *Nephelium litchi*, N. O. Sapindaceae . . . In addition to litchi, *Acacia farnesiana* and *Butea frondosa*, this insect has been grown on *Acacia concinna*, *Pithecolobium dulce*, *Z. jujuba* and *P. saman* . . . results of only scientific interest."

Notes.—In addition to the host, the most characteristic features recorded concerning this species may be briefly listed:—

"This [species] is a little more yellow and less chestnut in colour [than lac of *L. communis*, Mahdihassan] . . . Solely responsible for the lac industry in Mysore State; . . . smaller and its encrustation has smaller diameter than *Laccifer communis*; . . . differs from all the rest in not showing any such signs of parthenogenesis [as is the case with *L. communis*]; . . . distinct from all others, gives three crops of lac per year; . . . the next [to the] darkest lac is the product of" this insect, which is "the smallest commercial lac insect in India."

Mahdihassan records the following natural enemies (p. 23): *Eublemma amabilis*, *Brasema annulicaudis*, *Bracon tachardiae*, *Anatrachyntis falcata* ("is a sort of saprophyte feeding usually on dead lac insects"), *Holcocera pulverea*, *Lissencyrtus somervilli*, Mahdihassan, sp. nov., *Tetrastichus immisi*, Mahdihassan, sp. nov., and *Coccophagus tschirchii*, Mahdihassan, sp. nov.

It seems possible that this form is really racially or subspecifically distinct from *lacca*. It should be easily identified by means of its commonest host and its geographical distribution in Mysore.

***Laccifer communis* (Mahdihassan).**

1923. *Lakshadia communis* ("*F. mysorensis* insect"), Mahdihassan, Jl. Sci. Assoc. Maharaj. Coll. Vizianagaram, i, p. 52, lines 26-35; p. 53, line 1; pp. 1, 2, 12, 13, 14, 15, 17, 19, 20, 21, 22, 23, 29, 48 and other places.

Hosts.—"Usually forms its colony on *Ficus mysorensis*." "In addition to its favourite food-plant, it thrives sufficiently well on *Guazuma tomentosa*, *Anona squamosa*, *Zizyphus jujuba*, *Nephelium litchi*, *Ficus religiosa*, *Ficus bengalensis* and *Albizia lebbek*."

Notes.—"The darkest lac, almost garnet-coloured," comes from "*L. communis*"; "length of encrustation remarkably small" (compared to that of *L. mysorensis*); "when insects are healthy . . . the fresh specimens on *Ficus mysorensis* look beautiful pink or rose-coloured"; "when the young ones have evacuated the piece of stick lac, and the bodies of the mother insects have dried and shrivelled, the resinous encrustation has a brown red colouration, somewhat like a tea decoction"; distinctly larger than *L. mysorensis*; two life-cycles a year.

This "species" is probably a synonym of *lacca*, although perhaps forming a distinct race.

Mahdihassan records the following natural enemies: *Eublemma amabilis*, *Elasmus colemani*, Mahdihassan, sp. nov., *Erencytrus dewitzii*, Mahdihassan, gen. et sp. nov.

Laccifer chinensis (Mahdihassan).

1923. *Lakshadia chinensis*, Mahdihassan, Jl. Sci. Assoc. Maharaj. Coll. Vizianagaram, i, p. 52, lines 18-24.

Host.—None is given.

Notes.—"Next darkest lac [between *sindica* and *mysorensis*] comes from Assam and Indo-China. I feel sure that it is the same insect as found in South China, and also in Burma. The long spinoid process and the rib-like chitinous extensions of the stigmatic processes should be additional guides in its identification."

It is quite impossible to speculate safely as to the real identity of this species.

Laccifer sp.

1923. *Tachardia* sp., Chamberlin, Bull. Ent. Res. xiv, p. 173.

Remarks.—This species should possibly be referred to *Metatachardia*.

Genus **Metatachardia**, Chamberlin.

1923. *Metatachardia*, Chamberlin, Bull. Ent. Res., xiv, p. 172.

Remarks.—In accordance with other elevations in rank *Metatachardia* is here given full generic status.

Metatachardia conchiferata (Green).

1923. *Tachardia* (*Metatachardia*) *conchiferata*, Green, Chamberlin, Bull. Ent. Res., xiv, p. 172.

1923. *Lakshadia conchiferata* (Green), Mahdihassan, Jl. Sci. Assoc. Maharaj. Coll. Vizianagaram, i, pp. 53, 49.

1924. *Laccifer* (*Metatachardia*) *conchiferata*, Green, Cockerell, Psyche, xxxi, p. 47.

Subtribe TACHARDIELLI, nov.

Equivalent to the genus *Tachardiella* as previously recognised. It includes *Tachardiella* and *Austrotachardiella*.

Tachardiella larreae (Comstock).

1923. *Tachardiella larreae* (Comst.), Chamberlin, Bull. Ent. Res. xiv, p. 177.

1923. *Lakshadia larreae* (Comst.), Mahdihassan, Jl. Sci. Assoc. Maharaj. Coll. Vizianagaram, i, p. 53.

An additional record given me by Mr. P. H. Timberlake is, "Pigeons Pass, near Riverside, California, on 'greasewood'."

Tachardiella cornuta, Cockerell.

1923. *Tachardiella cornuta*, Ckll., Chamberlin, Bull. Ent. Res. xiv, p. 182.

The lot of material mentioned from Chihuahua, Mexico, is from "cerro chilocothe," not "ceno chilocothe."

Tachardiella mexicana (Comstock).

1923. *Tachardiella mexicana* (Comst.), Chamberlin, Bull. Ent. Res., xiv, p. 185.

1923. *Tachardiella texana*, Chamberlin, Bull. Ent. Res., xiv, p. 186.

Careful examination of an additional collection of this species from Brownsville, Texas, kindly loaned by Mr. Harold Morrison, of the U.S. Bureau of Entomology, has convinced me that the differences previously noted between *texana* and *mexicana* were due for the most part to the pathological condition of the specimens upon which the former species was based. After allowing for this factor the remaining differences seem to be too slight to separate the two forms specifically. In consequence of this *texanus* is here reduced to a synonym.

Tachardiella (?) argentina (Dominguez).

1907. *Tachardia argentina*, Dominguez, Autran, Las Cochenillas Argentines, Trabajos del Mus. de Farm. No. 18, p. 14.

1923. *Tachardiella argentina* (Doming.), Chamberlin, Bull. Ent. Res., xiv, p. 194.

Prof. T. D. A. Cockerell has kindly furnished me with some notes concerning this species. From these it is at once apparent that the species must be regarded as valid. We cannot, however, as yet, say whether it will fall in *Tachardiella* or *Austrotachardiella*. I quote Cockerell's communication in full.

"Eugenio Autran in Las Cochenillas Argentines, refers to *T. argentina*. He says Dominguez published it 'con lamina.' He calls it 'La Laca de la Tusca.' 'Esta producto, que se encuentra en abundancia en las ramas de la *Acacia cavenia*, en el provincia de Cordoba y que é veces la recubre por completo, se presenta ya en forma de mesas de aspect resinoso, de color rojo obscuro, aisladas, más ó menos voluminosas, redondeadas ú ovoides, de 5 á 8 mm. de diametro, 2½ á 3 de espesor, lisas endevior mente, convexas: ya en forma de costra giosera de 4 á 5 mm. de espesor.'"

Tachardiella cordaliae, Leonardi.

1923. *Tachardiella cordaliae*, Leon., Chamberlin, Bull. Ent. Res., xiv, p. 194.

Cockerell informs me that this species is supposed to be distinctly larger than *T. lycii*, measuring about 6.9 mm. in diameter. It is from Cacheuta, Argentine.

Tribe AUSTROTACHARDIINI, nov.

1923. "Supergeneric group of Austrotachardia," Chamberlin, Bull. Ent. Res., xiv, p. 194.

This group is raised to tribal rank in accordance with the general elevations made throughout this paper. It includes the single genus *Austrotachardiella*.

Subfamily TACHARDININAE, nov.

1923. Tribe Tachardinini, Chamberlin, Bull. Ent. Res., xiv, p. 199.

This subfamily includes the two genera *Tachardina* and *Afrotachardina*.

Genus **Afrotachardina**, Chamberlin.

1923. *Afrotachardina*, Chamberlin, Bull. Ent. Res., xiv, p. 199.

This genus was previously treated as a subgenus of *Tachardina*.

Tachardina albida, Cockerell.

1923. *Tachardina albida*, Cockerell, Chamberlin, Bull. Ent. Res., xiv, p. 206.

Under the "Remarks" concerning this species as given in my monograph (p. 206) the word *typical* at the beginning of the fourth line should, instead, be read as *atypical*.

Tachardina ternata, Chamberlin.

1923. *T. ternata*, Chamberlin, Bull. Ent. Res., xiv, p. 208.

This is the "Travancore insect" of Mahdihassan, which he fortunately does not name. Mahdihassan (*l.c.*, p. 29) records it from *Acacia sundra*. Green no doubt received his material from Mahdihassan himself.

Tachardina lobata (Green).

1923. *Tachardina lobata*, Chamberlin, Chamberlin, Bull. Ent. Res., xiv, p. 208.

1923. *Tachardina minuta*, Morrison, Mahdihassan, Jl. Sci. Assoc. Maharaj.

Coll. Vizianagaram, i, pp. 2, 12, 28-29, 30-33, 34, 38, 46 and 47.

1924. *Tachardina lobata* (Green), Cockerell, Psyche, xxxi, p. 47.

As shown by Cockerell and confirmed by Dr. David Starr Jordan, this species was erroneously considered as an unnamed and "new species" by the present author, instead of being credited to Mr. Green in my original treatise. This devolves, in a rather obscure way, upon the fact that in describing this species as a synonym of Morrison's *T. minuta*, Green, in addition, mentioned certain points of difference between his species and the Philippine form, and also noted the fact that he had previously distributed specimens under the manuscript name of *T. lobata*.

This is one of the "pseudo-lac insects" of Mahdihassan.

*Doubtful Species.***Tachardina silvestrii** (Mahdihassan).

1923. *Tachardina silvestrii*, Mahdihassan, Jl. Sci. Assoc. Maharaj. Coll. Vizianagaram, i, p. 30; pp. 2, 13, 28, 29, 30, 31 and 38.

Host-plant.—"Grows most frequently on *Ixora parviflora*, the 'Torchtree.'"

Notes.—Very closely allied to *Tachardia minuta*. Bangalore, India. *Ficus benjamina*, a host common to the "Mysore lac insect" (*Lakshadia mysorensis*) and the pseudo-lac insect of *I. parviflora* (*Tachardia silvestrii*). "The insect on the torch tree is even smaller [than *T. minuta*] and when both are fully grown this is nearly three-fourths in size to *T. minuta*." Cells of *minuta* dark chestnut in colour with a distinct tinge of purple, marginal lobes of test brownish blue colour "is distinct." The *Ixora* insect (*silvestrii*) is more orange-coloured than chestnut, while the fringe on the border line of the cells shows clear yellow colouration. "Two host plants common between them; sandalwood tree and *Guazama tomentosa*. The possibility of food affecting colouration therefore out of question. The presence of chains of bacteria prove it to be derived from the torch tree, *i.e.*, it is *T. silvestrii*." Yeast and chains of bacteria absent from *minuta* and "the Travancore insect."

A species of *Perisopterus* was bred from both *minuta* and *silvestrii*.

This species is undoubtedly one of the *Tachardina*. It seems probable that it is really valid, although, of course, this cannot be regarded as certain until it has been adequately redescribed.

A NEW *URANOTAENIA* (CULICIDAE, DIPTERA) FROM ALOR,
LESSER SUNDA ISLANDS.

By Dr. J. HAGA,

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***Uranotaenia kalabahensis*, sp. nov.**

Described from two females bred from larvae by Lieut. K. A. Aarstad, at Kalabahi, Isle of Alor, Lesser Sunda Islands, Dutch East Indies.

♀. *Head* entirely covered with flat greyish-brown scales and a margin of paler scales along the eyes; at both sides on the nape black upright forked scales. Antennae slightly longer than the proboscis, torus yellowish brown, other segments brownish black with brown verticils and small brown hairs evenly scattered along the segments. Palpi very short, one-eighth the length of the proboscis, which is slightly longer than the abdomen, apically enlarged and not abnormally hairy.

Thorax. Mesonotum: integument blackish, densely covered with long hair-like and narrow curved golden brown scales, greyish toward the front margin; without distinct ornamentation. A median row of small bristles and on each side a lateral row of strong black bristles with brown tips. Nowhere along the margin of the mesonotum or in front of the wing base are there any flat broad scales. Scutellum densely clothed with flat broad greyish-yellow scales. *Prothoracic lobes* with about 15 flat greyish scales. *Metanotum* brown. *Pleurae*: integument very dark brown. The *proepimeron* shows, just in front of the single proepimeral hair, two rows of broad flat greyish-bluish scales, together numbering eight and directed upwards. Apart from this, only the *sternopleurae* are scaled, viz.: (a) on the upper half, in front of the six upper sterno-pleural bristles, a patch of 18-20 broad flat greyish-bluish scales, directed backward and downward; (b) on the lower half a vertical row of 12 greyish-bluish scales directed backward and downward, just in front of the five lower sterno-pleural bristles. The *mesepimeron* with one lower bristle.

Wings with typical venation and entirely dark-scaled. The stem of the first fork-cell is $2\frac{1}{2}$ times as long as the cell and that of the second $1\frac{1}{2}$ times as long as the cell. The posterior cross-vein is slightly longer than the mid one, slightly sloping backward and two-thirds of its length inside the mid one and nearly thrice its length from the base of the third fork-cell. Long lanceolate scales on the branches of the first submarginal cell, on the greater part of the second long vein and on both sides of the third longitudinal vein, on both branches of the second fork-cell and on the upper side of the distal part of the upper branch of the third fork-cell; costal border very distinctly spinose. *Halteres* with ochreous stems and blackish knobs.

Legs: coxae and trochanteres with flat broad greyish-blue scales. Femora covered with brown scales, that show beautifully greenish blue in some lights. The legs elsewhere with light and dark brown scales and entirely unbanded. The ungues are small, equal and simple.

Abdomen dark brown, truncate; tergites blackish brown scaled, except the first and the base of the second tergite, which are yellowish grey scaled; sternites dark brown scaled, in some lights bluish.

Habitat: Kalabahi, Isle of Alor, Lesser Sunda Islands, Dutch East Indies, 1923.

Described from two perfect females. This species is well characterised in having the proepimera and the sternopleurae scaled, by the absence of blue scales along the margin of the eyes and of flat broad scales along the mesonotal margins, and because the mesonotum lacks distinct ornamentation.

The species differs from *Uranotaenia papua*, Brug (1) by the absence of a row of flat greyish scales along the margin of the mesonotum; (2) by the presence of a patch and a row of bluish scales on the upper and the lower part of the sternopleurae; (3) by the paler and much coarser vestiture of the mesonotum. It differs from *Uranotaenia testacea*, Theo. (Theobald, Monograph of the Culicidae, iv, pp. 560-561) (1) by the absence of a row of blue scales along the margin of the eyes; (2) by the presence of greyish blue scales on the proepimerum, which are lacking in *U. testacea*, at least in the description; (3) in the pleural ornamentation, for *U. testacea* shows a row of blue scales crossing the pleurae, at both sides of which the integument is much darker, while in the new species the ornamentation of the sternopleurae is quite different; (4) in the proportion of the length of the stem of the second longitudinal vein and that of the first fork-cell. Theobald states of *U. testacea*: "stem of the first submarginal twice as long as the cell;" in our specimens the stem of the first submarginal is $2\frac{3}{4}$ times as long as the cell.

The new species agrees with *U. testacea* in one point, viz., the prothoracic lobes are scaled, only these scales are not "azure blue" as in *U. testacea* but greyish.

***Uranotaenia papua*, Brug.**

On the 31st January 1924, Prof. Rodenwaldt presented to our laboratory 12 *Uranotaenia*, bred from larvae, collected on the Isle of Haroekoe near Amboina (Moluccas, Dutch East Indies). They all proved to be undamaged specimens of *U. papua*, Brug, and fortunately three of them were males (this Bulletin, xiv, p. 433). The description of the species by Brug may be completed thus:—The proepimeron shows a patch of small flat scales (in perfect specimens 18 scales) just in front of the single proepimeral bristle; these scales are greyish, but in some lights bluish. Prothoracic lobes with three strong bristles and several small flat broad greyish scales.

EFFECT OF SALT CONCENTRATION AND REACTION ON THE DEVELOPMENT OF *ANOPHELES* LARVAE.

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There is to-day a considerable body of information concerning the relation of Anopheline mosquitos to malaria transmission, but there is a scarcity of data on the factors influencing the development of these mosquitos. Such data are of more than theoretic interest, since a more detailed knowledge of the physico-chemical factors influencing Anopheline development may prove of considerable value in practical control.

Prompted by these considerations, we undertook a study of the relation of such factors as temperature, salinity, reaction of the water, etc., on Anopheline development. In this paper we present the data on the effect of salinity and reaction on some of the common house-visiting *Anopheles* found in Palestine.

In studying the effect of salt on *Anopheles*, it is necessary first to differentiate between species which breed in sweet or slightly brackish waters and those which tolerate a fairly high degree of salinity. This is particularly important, because the statements encountered in the literature referring to the breeding of *Anopheles* in saline waters are often ambiguous and misleading.

There is apparently a fairly large number of species of *Anopheles* that breed in water of high salinity. *A. multicolor*, found in Palestine and also in Egypt, breeds in sea-water and in salt-water basins having a salinity as high as 4 per cent. The optimum salinity for this species is not yet established. Other species have been reported from various parts of the world. Dutton reported that in Gambia *A. costalis* bred in salt-water pools; Balfour found the same species in Khartoum in water having a salinity of about 2 per cent. De Vogel, working with larvae of *A. rossi* (?) found that they tolerated 2.9 per cent. of salt. Foley and Yvernault report *A. chaudoyei* (a synonym of *A. multicolor*) breeding freely in sea-water in Algiers. Smith reports the breeding of *A. quadrimaculatus* (?) in the saline waters of New Jersey, and *A. crucians* under similar conditions in New Jersey and Louisiana, but he fails to state the degree of salinity. Darling reports the breeding of *A. albimanus* in swamps containing 1.93 per cent. salt. Griffiths reports that *A. crucians* was found to propagate in 50 per cent. sea-water, and was not affected unfavourably by a transfer to pure sea-water. Other authors refer to the breeding of one or another species of *Anopheles* in "brackish waters," but the term brackish is too vague to have any value.

Our experiments were confined to the fresh water species. After we had satisfied ourselves that *A. multicolor* breeds freely in water having a salinity of 2 to 4 per cent., we attempted to determine whether the ordinary Palestinian fresh water varieties, known to be malaria vectors, would tolerate saline waters and, if so, the degree of salinity they could stand. This question was especially important from the practical standpoint of mosquito control.

Our experiments fall under three headings:—

- (1) Do *Anopheles* show any preference in their egg-laying?
- (2) Effect of salinity on the freshly-laid eggs.
- (3) Effect of salinity on hatched larvae (usually first stage).

Relation of Salinity to Egg-laying.

The first series of experiments was statistical in character. Full-grown female mosquitos with ripe ovaries were placed in mosquito cages and salt-cellar or water-glasses containing different salt solutions or sea-water dilutions were placed irregularly on the bottom of the cage. Every morning the glasses were removed and the batches of eggs laid in each dish recorded. These observations were continued throughout the entire active breeding season—May to October, inclusive.

The results are shown in Table I:—

TABLE I.—Egg-laying of *Anopheline* Mosquitos in Waters of different degrees of Salinity.

Species of mosquito.	Total layings.	Fresh water.	Number of batches of eggs laid in various salt solutions.		
			M/8.	M/4.	M/2.
<i>A. elutus</i>	126	76	21	16	13
<i>A. sergenti</i>	135	91	32	9	7
<i>A. superpictus</i>	33	13	13	4	3

Sea water Dilutions.

		0 per cent.	12½ p.c.	25 p.c.	100 p.c.
<i>A. elutus</i>	37	10	13	11	3

It is apparent from these results that all the three species of *Anopheles* mosquitos show a decided preference for fresh water or water of a low salt content. In the salt solution experiments three-fifths and two-thirds of the total egg-layings of *A. elutus* and *A. sergenti* respectively were in fresh water. If the layings in fresh water and physiological salt solution are taken together, then the percentages of the total layings are: *A. elutus*, fresh water and M/8 NaCl, 77 per cent.; fresh water and high sea-water dilutions, 92 per cent.; *A. sergenti*, 88.5 per cent.; and *A. superpictus*, 78.8 per cent. Surprising though it may appear, all of these mosquitos seem in some way to be able to exercise selection with regard to salinity of the water and show a definite preference for fresh or slightly brackish water of a salinity of 0.5 per cent. to 0.85 per cent.

Effect of Salt Concentration on Hatching of Eggs.

The second series of experiments were made in order to ascertain the effect of various salt concentrations on the hatching of eggs. Different combinations were tried, always with the same results. In one series of experiments the eggs were left in the solution in which they were laid, and the dish covered so as to prevent evaporation; in another series, eggs laid in fresh water were transferred to different salt solutions; a third series consisted of eggs transferred from M/8 saline solution to various salt solutions; in still another series the eggs laid in various salt solutions were transferred to fresh water.

The results varied only slightly. In the first series there were five sets of layings in each concentration. In every case practically all the eggs laid in fresh water or M/8 saline hatched in 48 hours, while none of the eggs laid in M/4 and M/2 hatched.

In series 2 there were four experiments in which the eggs were transferred immediately from fresh water to different salt concentrations. Those transferred

to water or M/8 saline hatched in 48 hours, while of those placed in M/4 and M/2, in one experiment 2 to 3 larvae hatched and died at once. In the same series there were two experiments in which the egg transfer was made 24 hours after they were laid; in these experiments all the eggs hatched at about the same time, but those in M/2 died at once and those in M/4 died 24 hours after they were hatched.

In series 3 there were two sets of experiments with practically the same results. In M/2 none of the eggs hatched; in M/4 50 per cent. to 75 per cent. of the eggs hatched, and the larvae died in 24 hours; on the other hand, those in M/8 and fresh water hatched and remained active.

In the last series (from various salinities to fresh water) the results were the same as in the first.

The results are briefly summarised in Table II. It is apparent that salinities of M/4 or higher have a deleterious effect on the eggs and larvae of the *Anopheles* studied. This effect is readily seen with the naked eye and under the microscope. To the naked eye the eggs appear blanched, and when examined under a low power they are seen to be swollen and distorted, and occasionally the egg wall is burst. Eggs kept in fresh water long enough to permit the hardening of the chorion are not affected by the high salinity in so far as hatching is concerned, but the young larvae die shortly after they are hatched. On the other hand, eggs laid directly in water of high concentration are immediately affected by the salt, and none of them hatch.

TABLE II. *Effect of Salinity on Hatching of Anopheline Eggs**

Type of experiment.	Number of experiments.	Average per cent. of eggs hatched in salt solutions			
		Fresh water.	M/8.	M/4.	M/2.
Eggs left in original solution.	5	All	All	0†	0†
Eggs transferred from fresh water to various salt solutions shortly after they were laid	4	All	All	3 eggs in one; larvae died at once.	3 eggs in one exp.; larvae died at once.
Eggs transferred from fresh water to salt solutions one day after they were laid.	2	All	All	All; larvae died at once.	All; larvae died in 24 hours.
Eggs transferred from M/8 to various salinities.	2	All	All	50 p.c. in 1, 75 p.c. in 2; larvae dead in 24 hours.	0†

* Eggs of *A. elutus*, *A. sergenti* and *A. superpictus* were used in these experiments.

† Eggs invariably blanched.

Effect of Salinity and Reaction on the Development of Anopheline Larvae.

The previous experiments show clearly that salt in higher concentrations has a toxic effect on eggs and young larvae. The purpose of the next series of experiments was to carry this observation a step further and determine the effect of the combined factors, salinity and reaction of media, on the development of young larvae. For this purpose a large series of experiments were performed under various conditions.

The results obtained in this series were not so uniform as those in the first two, because of the difficulty in controlling all of the variables. One of the difficulties encountered early in the experiments was the maintenance of a constant reaction in the various salt concentrations and in ordinary water. The tendency was for the solutions to become alkaline. To obviate this difficulty we finally resorted to the use of small amounts (5 cc. M/15 solution to 45 cc. water or saline) of phosphate solutions as a buffer, and added the desired indicator to the water or salt solution. This enabled us to keep the reactions fairly constant, to follow the changes from day to day, and make the necessary corrections.

However, even with these precautions there were too many variables to give uniform results. Even if one succeeds in keeping the reaction and salt concentration constant, there are variations due to salt effect, food supply and bacterial growth, which we have not as yet attempted to regulate. Nevertheless, on analysing the large number of experiments that we have made to date there appear to be certain effects which are fairly uniform and sufficiently constant to warrant reporting at this time.

In ordinary water, tap or distilled, buffered and adjusted to various reactions, the reaction exercises a decided effect on young larvae. They grow more rapidly and are more active in acid than in alkaline solutions. The optimum reaction for *A. elutus* appeared to be pH 6.6, but the larvae tolerated reactions ranging from pH 8.0 to pH 5.5 with the aforementioned difference in effect. The stimulating effect noted in acid solutions was only temporary in character (at least under the conditions of the experiments) and after a week or so there was a tendency towards equalisation. The larvae in the more alkaline solutions soon began catching up with those in the acid media.

In salt solutions the results are more variable, but essentially the same, with the effect of the reaction somewhat accentuated. In salt concentrations higher than M/4 the larvae die promptly whatever the reaction. In salt concentrations lower than M/8 the reaction of the substrate apparently plays a significant rôle, which varies with the salt concentration. In alkaline solutions (pH 8.0) the larvae are distinctly smaller and less active than in the acid, and they survive much shorter periods in M/16 and M/32 salt solutions than they do in M/8 solutions. In the acid media for reactions pH 5.8 and 6.8, M/16 and M/32 are the optimum salt concentrations, while M/8 salt solution is less favourable. In other words, there appears to be an inverse relationship in the respective effects of salinity and reaction on larvae. In alkaline substrates a higher salinity is more favourable, while in acid substrates the higher salinity is less favourable.

It is evident, however, that this phase of the problem requires more detailed study with more careful control of the variables, such as food, optimum temperature, etc. Our experiments have gone far enough to show, on the one hand, that a reaction effect is not as simple and clean cut as MacGregor supposed; and on the other, that under a given set of conditions the reaction does exert an influence on larval development, a fact which may be of value in limiting breeding under those conditions. The fact that such a possibility exists warrants further study along this line.

Summary.

Experiments are reported on the effect of salinity on *Anopheles* larvae. It is shown that *A. elutus*, *A. superpictus* and *A. sergenti* show a decided selective capacity for egg-laying, depositing more than 75 per cent. of their layings in fresh water or water of low saline content. It is also shown that salt concentrations of M/4 and higher are toxic to these eggs and larvae. In so far as reaction is concerned a slightly acid reaction (pH 6.6 to 6.8) favours more active development, although larvae

will develop in alkaline solutions. The reaction of the medium also seems to modify the effect of the salinity. In an alkaline substrate M/8 salt solution is more favourable than lower salt concentrations, whereas in acid substrates the reverse seems to be the case.

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DESCRIPTIONS OF SOME NEW GENERA AND SPECIES OF COCCIDAE.

By F. LAING, M.A., B.Sc.

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The following descriptions are based upon material submitted to me by the Director of the Imperial Bureau of Entomology. These species form but a very small part of the material which has gone, through the continuous efforts of Dr. Marshall, towards the growth and enrichment of the National Collection of Coccidae, and I wish to record my very best thanks to him. To Mr. E. E. Green I am indebted for his unfailing courtesy, helpful comments and gifts of material from his private collection.

***Halimococcus nesiotus*, sp. n. (fig. 1).**

Adult ♀ completely enclosed by a hard, rigid puparium which is concealed by a closely felted, cottony covering composed of very short fibres. Puparium deep reddish brown, narrow oval, rounded in front, tapering behind, low convex above, flattened ventrally along line of attachment to the leaf; with minute antennae on the frons composed of several small setae situated on a tubercle; dorsum with a median longitudinal carina, with a series of depressions in either side. Operculum not elevated, of a paler colour than the rest of the puparium. Microscopically the marginal area is studded with minute spicules. Length 0·7 to 0·9 mm.; breadth approximately 0·45 mm.

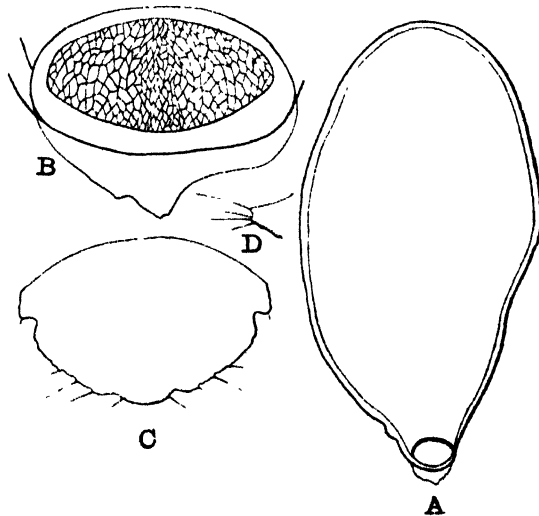


Fig. 1. *Halimococcus nesiotus*, Laing, sp. n.: a, puparium; b, operculum of puparium; c, anal segment of adult ♀; d, antenna of ♀.

Adult ♀ relatively of same shape as puparium which it approximately fills. Derm very delicate and it is extremely difficult to extract the female from the puparium. Antennae rudimentary, situated on tubercles with three long setae and one shorter and more delicate at apex. Rostrum strongly developed. Legs absent. Anal segment somewhat pygidiform, chitinous, of the same general shape as operculum of puparium; margin on either side with four setae directed laterally. Length 0·7 mm.

LORD HOWE ISLAND: on a species of palm (*H. W. Simmonds*).

Phenacoccus trinidadensis, sp. n. (fig. 2).

Adult ♀ elliptical, not quite twice as long as broad. Antennae 9-segmented, the proportions of the segments being in the ratio of 14, 14, 22, 18, 16, 14, 16, 14, 19; an 8-segmented form appears also to be present, the segmental proportions being 25, 26, 40, 30, 30, 30, 30, 38, the reduced number of segments not being due as far as can be judged to fusion, but to the actual dropping out of a segment between the third and seventh. Eyes conspicuous. Legs normal, tarsi less than half the length of tibiae; both pairs of digitules long, slender, reaching beyond apex of claw; claw strongly developed with a well-marked tooth a little nearer the apex than the base. Numerous dorsal short, sharp pointed slightly lanceolate spines present in an irregular transverse series about the middle of each abdominal segment but without regularity towards cephalic end and occasional long slender setae. Pores numerous, trilocular. Cerarii 36, the two interantennal pairs sometimes incompletely fused, resulting in one pair, all strongly chitinated, each chitinous area sharply defined; each cerarius with numerous short pointed spines with a tendency towards being lanceolate in shape, and large trilocular pores, not crowded together; anal cerarius with an average of about 20 spines, the spines on the remaining cerarii varying in number from 8 to 15; no auxiliary setae. Stigmata conspicuous with wide external opening. Dorsal osteoles scarcely noticeable, no ventral median osteole. Length 3.1 mm.; breadth 1.8 mm.

TRINIDAD: Toco Beach, on *Coccoloba uvifera* (C. L. Withycombe).

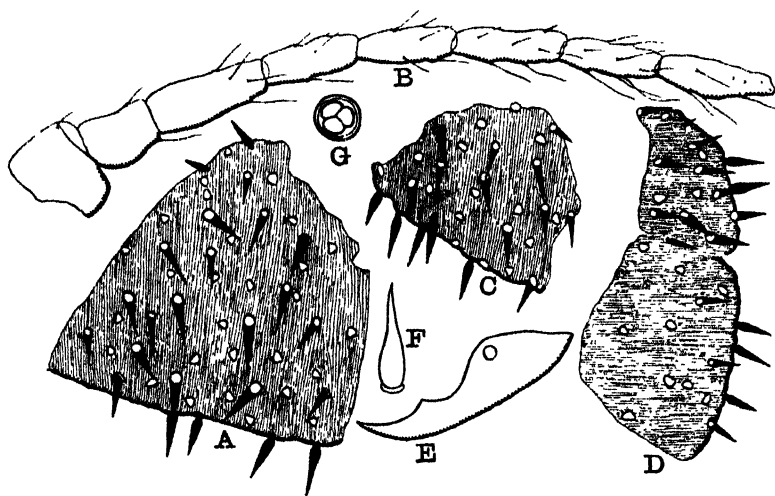


Fig. 2. *Phenacoccus trinidadensis*, Laing, sp. n.: a, anal cerarius; b, antenna (8-segmented form); c, fourth cerarius from anus; d, interantennal cerarii partly fused; e, claw of hind leg; f, type of body spine; g, trilocular cerarian pore.

Pseudococcus hargreavesi, sp. n. (fig. 3).

Adult ♀ ovate, slightly narrowed posteriorly, about one-third longer than broad. Labium elongate, pointed, longer than broad, as long as or slightly longer than the tentorium; 2-segmented, apical segment longer than basal. Antennae 8-segmented, all except the basal segment more or less elongate, 2, 3 and 8, considerably longer than the others; proportions of segments 30, 40, 35, 25, 28, 27, 27, 53. In addition to the usual slender setae there is a strong falcate spine at distal extremity of the 7th segment; a similar spine at about the middle of the 8th, and one if not two sinuous spines near its apical extremity. Limbs strongly developed, all of approximately

equal size; tarsus of hind limb one-quarter length of tibia. Claw without a denticle. Tarsal digitules slender, knobbed at the extremity; ungual digitules slightly stouter, abruptly expanded at extremity. Hind coxae without conspicuous translucent pores. Cerarii conspicuous, consisting of 18 pairs, each set on a slight prominence; caudal cerarius rather strongly chitinated, the chitinous area sharply defined, the previous two or three cerarii more slightly and indefinitely chitinated. The interantennal

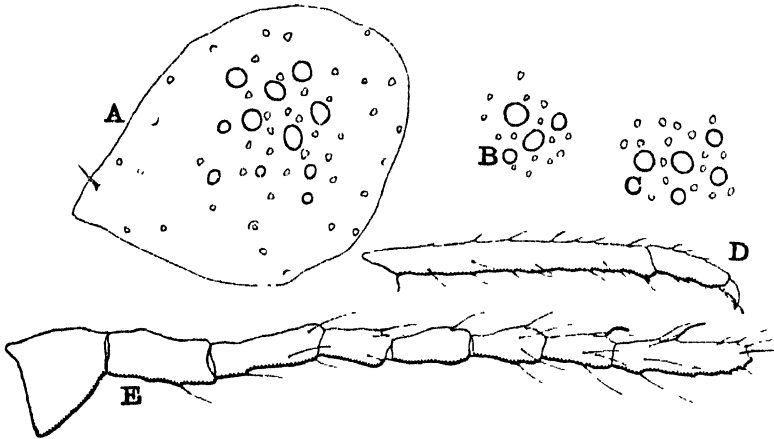


Fig. 3. *Pseudococcus hargreavesi*, Laing, sp. n.: a, anal cerarius; b, interantennal cerarius; c, antepenultimate cerarius; d, tibia and tarsus of posterior leg; e, antenna.

cerarii with three (sometimes there is another smaller one), the remainder with from four to six conspicuous circular discs which are probably the sockets of spines that have become detached, other smaller discs probably indicate the positions of missing auxiliary setae. (It is remarkable that not a single spine or auxiliary seta remains on some 18 specimens examined; even the caudal setae are missing and their position indicated by a large disc surmounted on the usual small tubercle.) A group of longish setae between the antennae and between the attachment of the limbs. Posterior spiracles considerably broader than the anterior. Dorsal osteoles rather pronounced, with thickened lips; medio-ventral osteole not apparent. Obscurely triangular pores distributed profusely over the whole body, not markedly clustered on cerarii. Discoid pores in a crowded series across the genital segment and in looser series across the preceding two or three segments. Length 2.75 to 3.25 mm.; breadth 1.75 to 2.25 mm.

UGANDA: Kampala, on *Bauhinia* sp. (*H. Hargreaves*).

Near to *P. crawii*, Coq., but differing from that species in the unusually long third antennal segment, and in having 18 pairs of cerarii instead of 17. Resembles *P. wistariae*, Green, in some respects, but the latter species has two spines only on the caudal tract.

***Pseudococcus ugandae*, sp. n.**

Adult ♀ broadly ovate with small rounded caudal lobes, greatest breadth about three-quarters the length. Labium elongate, fully twice as long as it is broad; 2-segmented, relative proportions of basal to distal segments as 5 to 6. Antennae 8-segmented, scantily setose, an obscure division across the 8th segment suggests a tendency to a 9-segmented form; relative proportions of antennal segments 25, 29, 30, 20, 25, 20, 22, 45. Legs large and robust, third pair longest; tibia of hind pair nearly four times the length of the tarsus; tibia of first pair less than three times the length of the tarsus. Claw stout, without a denticle. Ungual digitules extending

beyond the tip of the claw, dilated at the extremity; tarsal digitules long, slender, also dilated at apex, extending to tip of claw. Hind coxae without conspicuous translucent pores. Cerarii confined to the posterior 5 or 6 abdominal segments, each with one or two small, somewhat spear-shaped spines, the three posterior with two spines, and the two or three cerarii anterior to those usually with one. Caudal cerarius not markedly chitinised. Caudal setae scarcely longer than those of the anal ring. Body setae sparse except on the frontal area. Small triangular pores sparsely distributed. Large discoid pores crowded on posterior four segments of the abdomen; a few short tubular pores at intervals along the marginal area. Medio-ventral osteole dumb-bell shaped. Length 3.5 to 3.75 mm.; breadth 2.5 mm.

UGANDA: Kakumiro, on *Grevillea robusta* (H. Hargreaves).

This species has characters approaching but amply distinct from *P. eriogoni*, Ehrh.

***Farinococcus simmondsi*, sp. n. (fig. 4).**

Adult ♀ of a pale fulvous brown (in formalin), about one-third longer than broad. Margin not produced into prominent lobes except the interantennal and anal pairs which are a little more conspicuous. Antennae 7-segmented, segments in the proportions of 15, 13, 11, 16, 9, 10, 21. Eyes well defined. Legs well developed, the femur and trochanter together subequal to the combined length of tibia, tarsus and claw; tarsus a little more than half the length of tibia; ungual digitules dilated at tip, tarsal digitules simple. Marginal ceriferous tracts ill-defined, more or less confluent

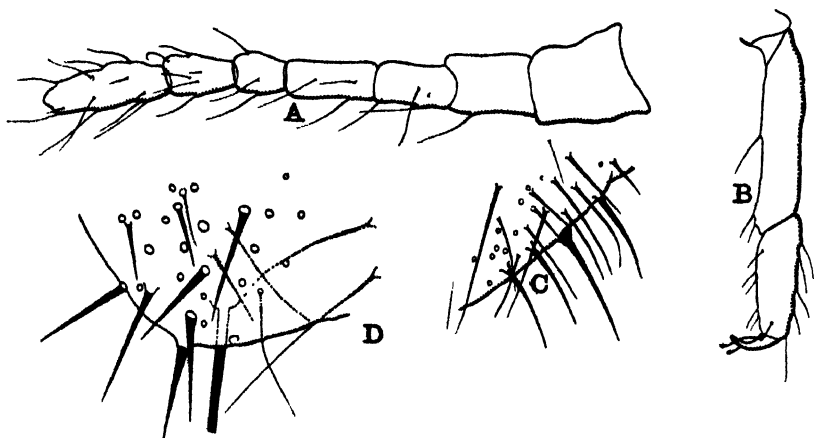


Fig. 4. *Farinococcus simmondsi*, Laing, sp. n.: a, antenna; b, tibia and tarsus of hind leg; c, antepenultimate cerarius; d, anal cerarius.

except at cephalic end where they are slightly demarked; each tract with from 6 to 10 long, sharply pointed spines varying in thickness, and with many spiniform setae. Derm with numerous strong setae and with minute pores; venter with similar pores but larger. Caudal setae not quite twice as long as anal setae. Both pairs of osteoles conspicuous. Length 2.2 mm.; breadth 1.7 mm.

NEW BRITAIN: Kokopo, on coconut (H. W. Simmonds).

Tylococcus formicarii, Green, and *T. simplicior*, Green, two species described from Ceylon should both be transferred to the genus *Farinococcus*, a disposition to which Mr. Green agrees.

Kuwanina hilli, sp. n. (fig. 5).

Females enclosed in small sacs massed together and covered over by the fibres of the host plant; walls of the sacs thin and brittle but hard, white both inside and out. Naked ♀ dark red in colour; stains KOH purple.

Adult ♀ subglobular. Antennae rudimentary, consisting of 4-5 spinose setae on a well-developed tubercle. Legs absent. General surface of derm covered with circular pores, medium in size; these pores, or pores of approximately the same diameter, thickly crowded, two to three rows deep around both pairs of spiracles. Lying immediately posterior to the hinder pair of spiracles is a large cribriform

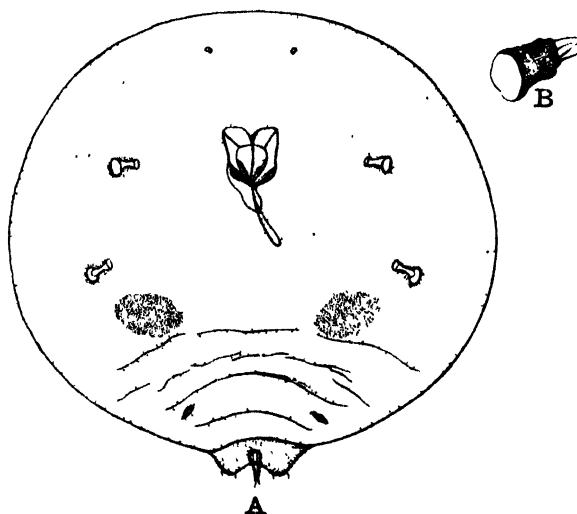


Fig. 5. *Kuwanina hilli*, Laing, sp. n. : a, adult ♀; b, antenna.

plate-area, not strongly demarked, broader than long, thickly crowded with circular pores of about half the size of the general body-pores. Posterior end of body indefinitely segmented, last segment slightly more strongly chitinised than the remainder of the body, rugulose, produced into two low lobes with anal ring in the hollow. Anal ring with six setae projecting beyond the adjacent lobes. A few scattered hairs around the margin and on the body. Total length subequal to breadth, 2.2 mm.

QUEENSLAND : Homehill, on Onion-weed (*G. F. Hill*).

Coroplastodes ritchiei, sp. n. (fig. 6).

Adult ♀ oval in shape, not quite twice as long as broad. Antennae vestigial, composed of a base showing no signs of segmentation, and a bunch of strong setae at the apex, the longest seta shorter than the length of the antennal stump. Spiracles large, cylindrical; stigmatic spine single, very long, tapering; an irregular series of small circular pores connecting the base of the stigmatic spine with the spiracle. Legs vestigial, the different parts indistinguishable, with the claw present but very small; tarsal digitules thread-like, not reaching beyond the claw, present at least in the second and third pairs of legs. Abdominal segments very distinct. Dorsum with many small circular pores into which lead short cylindrical ducts. Ventral surface with many large circular glands of the disc type arranged transversely across the segments for some distance in front of and crowded posterior to the anal lobes.

Marginal spines in a single row, short, sharp-pointed, broad-based and situated at irregular intervals; one or two considerably longer spine-like setae on posterior margin; a marginal area adjacent to anal cleft spinulose. Anal plates widely separated with a very strong spine situated on a prominence, with a seta on either side, on inner margin. Length 3.5 mm.; breadth 1.9 mm.

TANGANYIKA TERRITORY: Government Experimental farm, Morogoro, on fruit of Soursop (*Anona* sp.) (A. H. Ritchie).

This is a typical *Ceroplastodes* with the exception of the vestigial character of the antennae and legs.

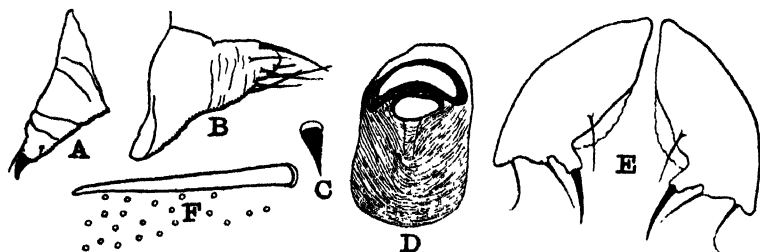


Fig. 6. *Ceroplastodes ritchiei*, Laing, sp. n.: a, rudimentary leg of adult ♀; b, antenna; c, marginal spine; d, spiracle; e, anal plates; f, stigmatic spine.

Cyphococcus, gen. nov.

Belonging to the COCCINAE. Very low convex, a rather broad median longitudinal dorsal area stretching from a little in front of anal lobes to near anterior end strongly demarked and showing segmentation well; no secretion (alcoholic material); a longitudinal row on either side of discal area and immediately exterior to it of four truncate conical protuberances resembling small molluscan shells of the genus *Puncturella*; these protuberances frequently broken off but the areas they occupy are visible. Adult ♀ with antennae and legs rudimentary; margin closely set with short, spear-shaped spines; stigmatic spines in clusters consisting of two sizes, a series of three or four large spines and a series of much smaller spines, both series of same general shape with rounded apices; anal ring setae ten in number. Dorsum with a continuous narrow belt of filiform pores and short sharp scattered spines stretching from immediately in front of anal plates to beyond the antennae, this belt coinciding with the discal area seen in the fresh adult; four lateral secondary sub-circular belts given off externally corresponding with the dorsal conical protuberances.

Genotype, *Cyphococcus caesalpiniae*, sp. n.

Cyphococcus caesalpiniae, sp. n. (fig. 7).

Adult ♀ pale castaneous brown (in alcohol), low convex, broadly ovate, a broad median dorsal longitudinal demarked area sharply pointed in front or else the two pointed ends scarcely meeting but running towards anterior margin to form a narrow sulcus, broadly rounded posteriorly, stretching from immediately in front of anal operculum to near cephalic margin; segmentation of this discal area strongly marked; external and adjacent to this discal area and medianly situated on either side are four conspicuous, truncate, dull black conical protuberances, vertically striated about 1 mm. high. Average size 12 mm. long by 9 mm. broad.

Adult ♀ with many dorsal vacuoles especially marked posteriorly and anteriorly where they are irregularly arranged, but laterally they are in more or less transverse bands; most of the vacuoles with the opening of a spinneret in or near its centre. Submedianly an oval, narrow continuous belt stretching from just in front of anal

operculum to slightly anterior to antennae consisting of an irregular double or treble row of conspicuous fairly closely packed filiform pores with at intervals short, sharp-pointed spines; on either side of main belt and external to it arise in the median area four similar bands, subcircular in form, with the spinnerets at less frequent intervals and not so conspicuous and apparently without the short spines: these belts coincide with the circumferences of dorsal protuberances. Margin closely set with strong, short, spear-shaped spines situated apart at a distance equal to or slightly less than length of a single spine; one or two spinnerets leading into base of each spine; large conspicuous, circular glands situated at remote intervals close to margin. Stigmatic spines in clusters consisting of two sizes, the larger of three spines the middle of which is longest, and the smaller of a bunch of a dozen or more (several may be

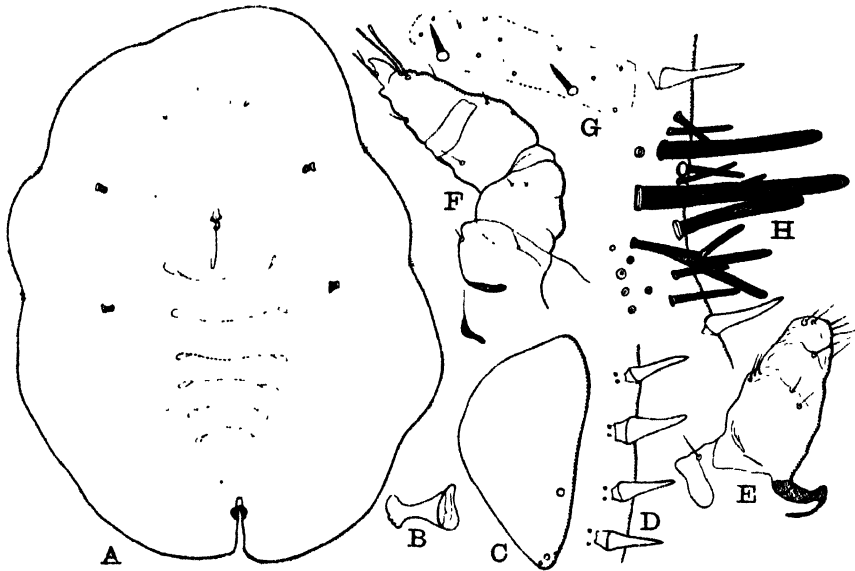


Fig. 7. *Cyphococcus caesalpiniae*, Laing, gen. et sp. n.; a, adult ♀; b, spiracle; c, anal plate; d, marginal spines; e, antenna; f, hind leg; g, a small part of the dorsal belt of filiform pores and spines; h, anterior spiracular spines.

broken off) of approximately equal size, all straight with rounded tips. Stigmata conspicuous, connected with a well-developed tracheal system. Antennae rudimentary, with a few spinose setae at apex. Legs rudimentary but each segment discernible, both ungual and tarsal digitules long, slender, apices knobbed. Anal lobes with outer angle well rounded, both outer margins subequal in length; two spines apically, one posterior to the other, a third near middle of inner margin; dorsal surface rather rugose; anal ring broad, closely perforated; ten well-developed anal setae. Total length approximately 13 mm., breadth 01 mm.

UGANDA: Kampala, on *Caesalpinia dasyrachis* (H. Hargreaves).

***Lecanium inopheron*, sp. n. (fig. 8).**

Adult ♀ (in alcohol) pale castaneous brown, low to medium convex, elongate-ovate, widest across region immediately in front of anal operculum, middle portion of dorsum with from 5 to 6 well-marked transverse ridges, eyespots black, conspicuous, a short way in from margin. Average length 10 mm., breadth 8 mm.

Antennae 8-segmented, very slender, third segment waisted, second with a very long seta, eighth with five medium setae and a long apical one, other segments with

few; proportions of segments, 10, 63, 30, 25, 15, 11, 17. Legs normal, tarsi approximately half length of tibiae, the two together subequal to femur and trochanter; claw with a small basal tooth; tarsal digitules long, slender, knobbed, ungual digitules broadly dilated extending well beyond claw. Dorsum with translucent dermal spots, fairly conspicuous but not crowded; filiform spinnerets very plentiful. Posterior segments of abdomen well marked. Venter with circular discoid pores crowded around genital orifice and extending into four posterior segments, becoming absent anteriorly; a pair of long setae situated slightly cephalad of genital orifice. Marginal spines closely set, situated apart at a distance about equal to length of a single spine, strong, truncate at apex, in some specimens a duct clearly visible leading into base of each. Margin of anal cleft spinulose. Stigmatic cleft not very deep, with a prominence on either side giving a deeper and more sunken appearance to cleft; stigmatic spines of two sizes, the larger of 2 to 3, curved and with tips rather rounded, the smaller and more slender of about 4, with sharper tips. Stigmata with large mouths, cup-shaped. Anal lobes triangular, the two outer margins subequal and slightly shorter than inner, dorsal surface reticulate, several setae on central area, a short sharp pointed spine about the middle of inner margin, and two subapical ones, one of which is probably very long (all the specimens have this spine broken off short).

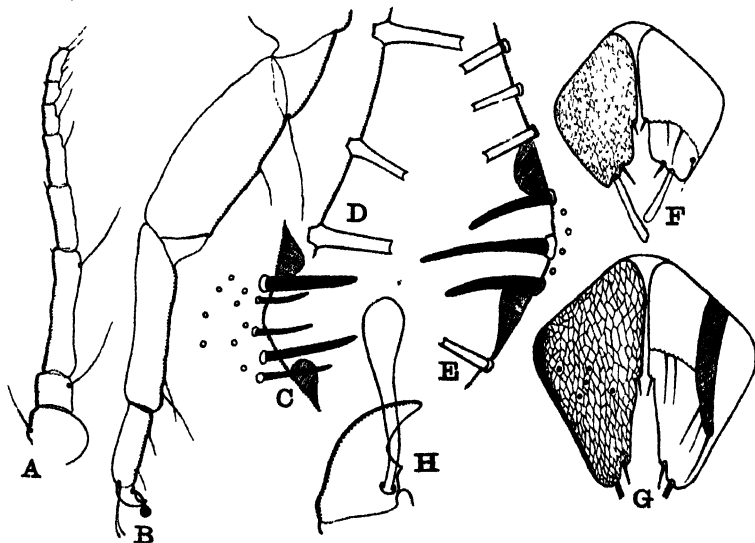


Fig. 8. *Lecanium inopheron*, Laing, sp. n.: a, antenna; b hind leg; c, anterior stigmatic spines; d, marginal spines; e, stigmatic spines of young adult; f, anal plates of young adult; g, anal plates of adult; h, claw of hind leg.

Immature specimens have 7-segmented antennae, three stigmatic spines, the middle of which is the longest, stigmatic clefts with prominences on either side, anal plates with a very long, rather broad, truncate, subapical spine, and other characters as in adult.

UGANDA: Kampala, on *Erythrina* sp. (H. Hargreaves).

Specimens which seem to be identical with *L. inopheron* in all respects except that they are slightly smaller and the antennae, if anything, slightly more robust have also been received from S. Nigeria (Ibadan) collected by Mr. O. B. Lean off American Cotton, and I have assigned them to this species.

L. inopheron is undoubtedly very closely allied to *L. filamentosum*, Newst., but differs from the latter species in the characters of the stigmatic cleft and the anal lobes.

***Platylecanium cocotis*, sp. n. (fig. 9).**

Adult ♀ dark reddish brown, flat, longish-oval, slightly narrower in front than behind, length about one-half greater than breadth, a median longitudinal ridge of white, brittle secretion (which may cover the whole dorsum) present. Adult clearing in potash to a very light brown; dorsum with numerous small tubercular glands scattered irregularly on submarginal area, but running in transverse series across the dorsum, these glands with a seta at tip; about six series between the antennae and anal plates. Dorsal areolations distinguishable submarginally. "Cribriform plates" four, on each side of the anal plates, the most anterior pair with practically no small pores but with three rather large vacuoles, the other three pairs with both small pores and vacuoles. Ventrally, two semicircular rows of large pores, lying anterior to anal lobes, the anterior crescent of pores continuous, the posterior series irregularly double, interrupted medianly. Legs absent. Antennae rudimentary, one-segmented. Margin crenulated, marginal setae simple, sparse. Spiracular spines three, sometimes four, rounded at apex, sunk in a deep marginal incision; a well-marked channel running inwards from the spines to near the spiracles; a short series of pores connecting the end of the channel with the spiracles. Spiracles with the outer end widely expanded, inner end narrow. Anal plates triangular, together diamond-shaped, about 240μ long, surrounded by a strongly chitinised area. Length approximately 6 mm.; breadth 4 mm.

NEW HEBRIDES: Efaate, on Coconut (*H. W. Simmonds*).

This species would appear to be most closely related to *P. cribrigerum*, Ckll., but differs from that species in the shape of the anal plates, in certain differences in the margin and in the presence of areolations on the marginal area. From *P. asymmetricum*, Morr., it differs in the shape of the body and in the antennae.

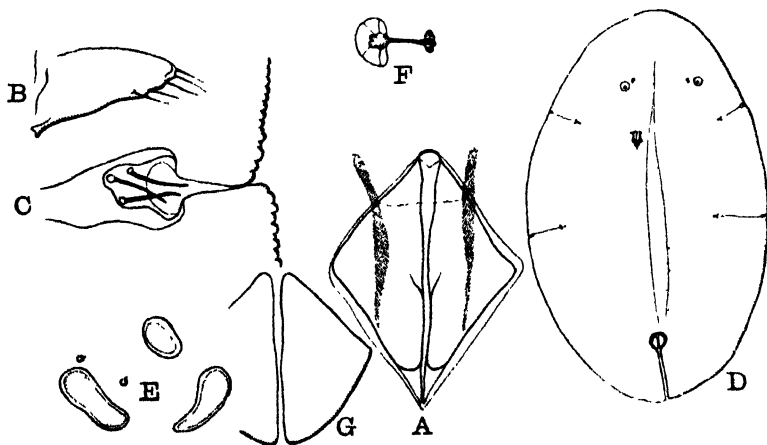


Fig. 9. *Platylecanium cocotis*, Laing, sp. n.: a, anal plates; b, rudimentary antenna; c, anterior spiracular spines; d, adult ♀; e, anterior-vacuoles of cribriform plate; f, spiracle; g, anal plate of *P. cribrigerum* (Ckll.) for comparison.

***Cryptostigma saundersi*, sp. n. (fig. 10).**

Adult ♀ (in alcohol) with a pale yellowish brown longitudinal stripe and several lateral intertwining stripes on dorsum and also several semicircular ones on the declivity anterior to anal lobes; remainder of dorsum of a darker brown; a small dark brown to almost black area around anal plates. Ventral surface dark brown with a paler marginal area. Length (unmounted) approximately 7 mm., breadth from 5 to 6 mm.

Antennae rudimentary, one segment only apparent with indications of two more compressed subobsolete basal segments; numerous setae at or near the apex. Legs greatly reduced, femur and tibio-tarsus present but small; claw present and well developed; tarsal digitules simple, extending to beyond the claw; ungual digitules short, slightly dilated at apex, reaching to a little beyond claw. Stigmatic clefts rather deep, without spines; the heavily chitinated collar at base of depressions thickly beset with small pores; the area between the mouth of the spiracle and the spiracular collar crowded with pores of disc type. Marginal spines small, conical, sharp-pointed, on broad bases. Ventral surface with two sizes of circular pores, the smaller scattered generally over the whole surface, the larger of the disc type scattered sparsely on marginal area and more crowded medianly, especially anterior to anal plates. Strong sharp setae from twice to three times the length of the marginal spines scattered sparsely over the surface but more numerous anterior to anal plates.

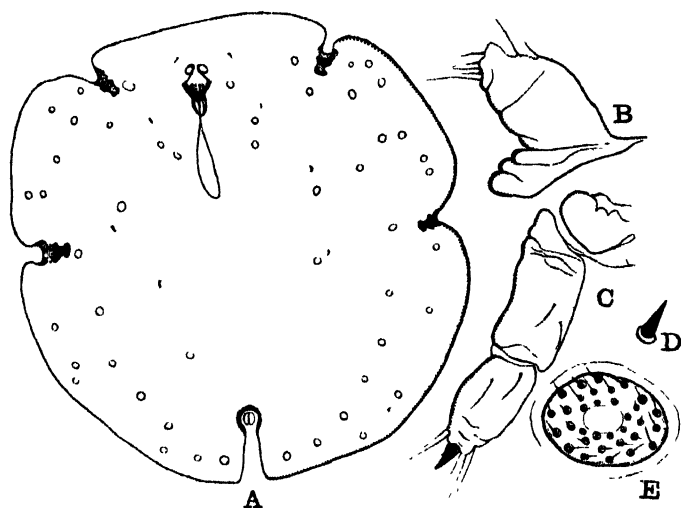


Fig. 10. *Cryptostigma saundersi*, Laing, sp. n. : a, adult ♀, to show distribution of "compound pores"; b, antenna; c, posterior leg; d, marginal spine; e, a "compound pore."

Dorsal surface with from three to four irregular longitudinal rows of "compound pores or plates" oval or subcircular in shape, each "plate" surrounded by a more or less distinct narrow clear area; the centre of the "plate" clear but sometimes filled with extraneous matter; the area between the thick rim and the central vacuole with from two to three irregular series of pores, the outer series having a seta arising from the centre of each pore. Whole dorsal surface covered with small circular pores of two sizes, the smaller bilocular, the larger of about twice the diameter and of the disc type. Anal plates surrounded by a heavily chitinated collar, each plate half ovate, rather deep, with five to six setae dorsally, and 10 to 12 around the apex and inner apical margin. Extreme length (mounted) from 8 mm. to 1 cm.; breadth 0.7 cm.

BRAZIL: Rio de Janeiro, on trunk of an undetermined tree, protected by ants belonging to an undescribed species of the genus *Azteca* (*L. G. Saunders*).

This very distinct species is readily separated by the numerous "compound pores" which are quite different in structure from those of *C. quinquepori*, Newst., the only other member of the genus possessing these structures.

***Chionaspis hargreavesi*, sp. n. (fig. 11).**

Scale snowy white, more or less parallel sided, occasionally slightly expanded posteriorly, very highly convex, the perpendicular sides of the median part sometimes faintly constricted; ventral scale membranous, white, adhering closely to surface of leaf; larval exuviae of a bright orange brown. Length approximately 1 mm.

Adult ♀ (dried) very dark brown to almost black, much contracted, especially so in pygidial region where segments are humped up and highly convex. When treated with KOH ♀ ovate, rather narrow in front, widening out to its greatest breadth about middle, gradually contracting posteriorly, posterior very broad with margin almost straight; greatest width about half the length. Antennal tubercles with usually one long strong curved seta, occasionally two. Parastigmatic pores wanting. Pygidium with median lobes very remote, reduced to small conical projections with a small shoulder on outer margin; second pair of lobes separated from first pair by a distance equal to half that between the median lobes, about twice size of latter, hastate in shape, with rounded apices and deep triangular bases projecting into pygidium; third pair of lobes represented by small conical projections which may be slightly notched on outer margin immediately beyond second pair; a fourth pair of lobes probably present in form of still smaller conical projections at a distance equal to about three-quarters of that between median lobes; a gland spine immediately beyond first pair and another beyond third pair of lobes; a pair of marginal gland pores in the interval between first and second pair of lobes. Circumgenital pores absent. Total length 1.2 mm.; breadth 0.6 mm.

UGANDA: Masaka, on leaf of "Nzo" (*H. Hargreaves*).

Near to *C. amaniensis*, Ldgr., for which MacGillivray has proposed the generic name *Inchoaspis*.

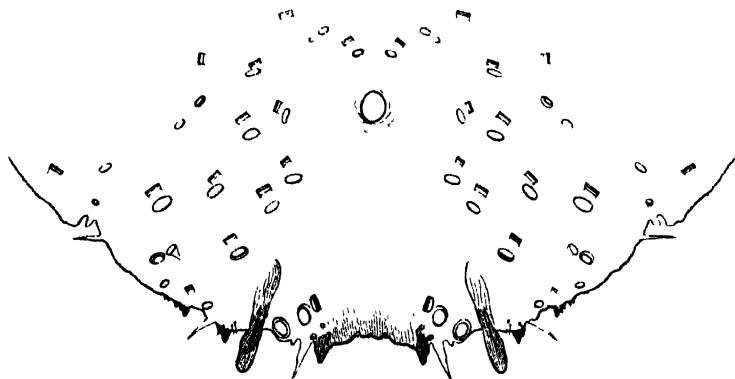


Fig. 11. *Chionaspis hargreavesi*, Laing, sp. n., pygidium of adult ♀.

***Phonacaspis australis*, sp. n. (fig. 12).**

Scale snowy white, narrow in front, very broad posteriorly, sometimes almost subcircular; exuviae brownish fulvous, the larval exuvium darker than nymphal. Total length averaging 3 mm.; breadth 2 mm.

Adult ♀ elongate, narrow, approximately twice as long as broad, relatively narrower at cephalic end than caudal. Rudimentary antennae situated on small tubercles with a single long seta. Anterior spiracles with a small group of parastigmatic pores, usually four to five; these absent from the posterior pair. Margins of abdominal segments with numerous pores and spiniform squamae; the two posterior segments with a horizontal medio-lateral series of four to five spinnerets

and a lateral series of six to seven. Pygidium with three pairs of lobes; median pair widely divergent, prominent, inner margins entire; second and third pairs duplex, the second lobule of each pair much reduced. Two setae in the interval between the median lobes and a spiniform squama and a spine in the corresponding interval between each pair of lobes. Two series of dorsal gland orifices, the posterior group of each series composed of about six glands, the anterior of about four; a third series represented by two glands lying adjacent to the space between the anterior and posterior groups of circumgenital pores. Circumgenital pores in five groups, the formula approximately 19:15:7:18:21.

Length 1.6 mm.; breadth 0.7 mm.

AUSTRALIA: New South Wales, Sydney, on an unidentified plant, probably a species of *Eucalyptus* (Dr. G. A. K. Marshall).

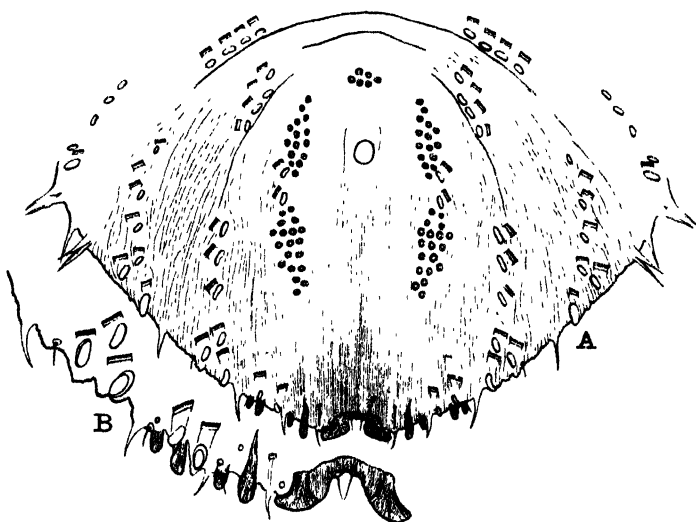


Fig. 12. *Phenacaspis australis*, Laing, sp. n.: a, pygidium of adult ♀; b, margin of same.

Operculaspis gen. nov.

Genus belonging to the *Aspidiotini*, resembling in shape members of the genera *Selenaspis* and *Pseudaonidia*, with a constriction between the pro- and mesothorax; abdominal segments distinct, the two posterior ones with a strong marginal spur; pygidium with on the ventral surface a large subcircular opening closed by means of an operculum hinged posteriorly, with one pair of lobes—the median—present, with a marginal fringe composed of long spiniform setae, and with two dorsal longitudinal tracts of setae merging in the pygidial fringe at the margin at a distance from the median lobes equal to the breadth of a median lobe and diverging backwards to considerably anterior to the operculum.

Genotype *Operculaspis crinitus*, sp. n.

In the shape of the covering scale from which the larval pellicles are absent and in the disposition of the male scales, situated often underneath the female puparia, this genus resembles *Conchaspis* but its affinities are entirely with such genera as *Selenaspis* and *Pseudaonidia*.

***Operculaspis crinitus*, sp. n. (fig. 13).**

Scale of adult ♀ white or greyish white, subcircular to broadly ovate, very moderately convex, very firm, rather brittle and thick; ventral scale present, closely adhering to bark of host plant, papery in texture in the young stage but hardening with age, and in mature individuals of about same thickness as dorsal scale. No trace of larval pellicles. Greatest diameter approximately 3 mm.

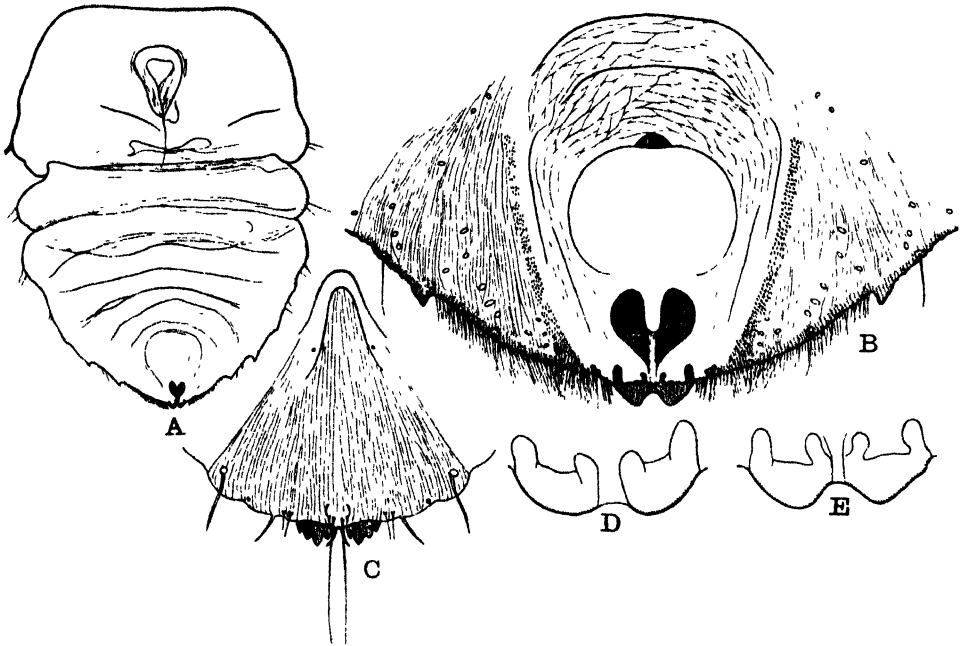


Fig. 13. *Operculaspis crinitus*, Lamg, gen. et sp. n.: a, adult ♀; b, pygidium of same; c, pygidium of larva; d, e, slight variations in shape of median lobe of adult ♀.

Adult ♀ dark brown, rigid, strongly chitinised about a quarter longer than broad; broad anteriorly, narrowing almost to a point posteriorly; frontal margin slightly concave, cephalic portion of body almost rectangular; a deep marginal constriction between prothorax and mesothorax where greatest breadth is; abdominal segments distinct. Long slender setae at intervals around margin. Antennae represented by three or four setae upon a minute tubercle. Both pairs of spiracles with minute parastigmatic pores like punctures just distinguishable in the hard chitin stretching in an irregular double line from the spiracles towards margin. Rostral setae very long. Dorsal pores minute, difficult to distinguish, present at least on anterior abdominal segments in transverse series; dorsal setae on abdominal segments also present. The two abdominal segments immediately anterior to pygidium with strong marginal spurs on posterior edges. Pygidium with a single pair of median lobes, fused basally, broad, shallow, rounded apically, deeply incrassated and thickened at both the outer and inner basal margins. Arising from between the lobes and running backwards into the pygidium is a prominent Y-shaped or bicornuate strongly chitinised process. Pygidial margin crenulated, closely set with a fringe of long slender setae. At a distance of slightly less than the breadth of a median lobe, on each side, dorsally arises a narrow spiniferous tract, confluent with pygidial fringe

setae at margin and running backwards in a slightly curved oblique direction towards anterior margin of pygidium, the spines decreasing in length until they become very short anteriorly. Ventral surface with a large subcircular median opening, lying immediately in front of the bicornuate process, and closed by an operculum which is hinged posteriorly. No circumgenital pores. Length approximately 1.7 mm.; breadth 1.3 mm.

The earlier stages before extreme chitination sets in show the long slender setae at frequent intervals around margin and scattered over the surface, the extreme length of rostral filaments, the distinct parastigmatic pores of about 20 stretched out towards the margin in an irregular row, the dorsal transverse series of circular pores on abdominal segments, and the conspicuous dorsal pygidial pores. The bicornuate chitinous process is not developed.

TANGANYIKA TERRITORY: Ngerengere, on a forest tree (*A. H. Ritchie*).

***Lepidosaphes marshalli*, sp. n. (fig. 14).**

Female puparium pale brown with usually a narrow paler margin, mytiliform, slightly curved, very broad posteriorly, the greatest breadth often approximately two-thirds the length; exuviae of a more yellow tint than the scale. Average length 3 mm.; breadth 2 mm.

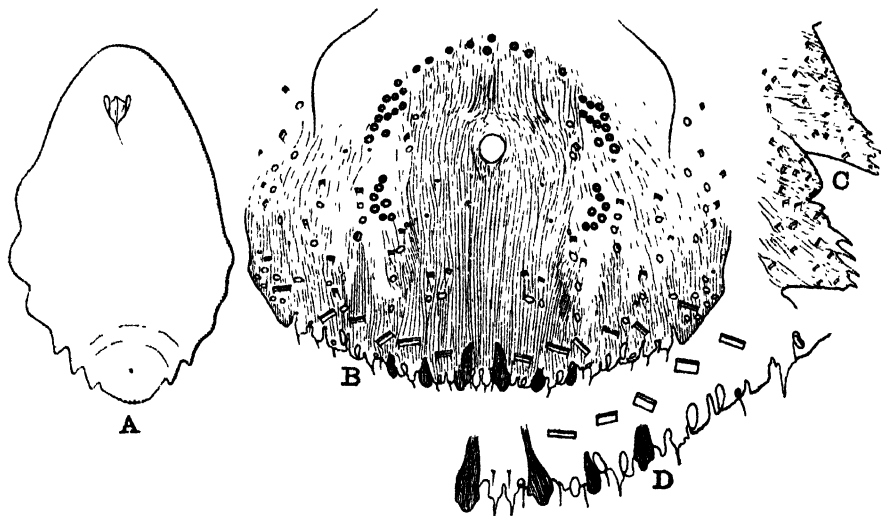


Fig. 14. *Lepidosaphes marshalli*, Laing, sp. n.: a, adult ♀; b, pygidium; c, lateral processes; d, margin of pygidium.

Adult ♀ longish oval, thoracic and abdominal segments well demarked, the posterior two abdominal segments produced laterally into ungulate processes armed with spiniform squamae; greatest breadth across first abdominal segment. Antennae composed of small tubercles with four long setae. Anterior spiracles with a crescent-shaped series of six to seven pores, which are absent from posterior pair. Marginal area of abdominal segments with numerous ducts. Pygidium very evenly rounded, with three pairs of lobes; median lobes rather widely separated, minutely notched on both outer and inner margins and extending basally rather deeply into the pygidium; the first lateral pair with the inner margin straight, the outer curved; the second pair more or less parallel-sided, the apex rather sharply oblique. A pair

of ligulate squamae produced at the tip into spiniform processes, between the median lobes and about six similar squamae beyond the third pair of lobes; in the intervals between the median and second and between the second and third pairs of lobes a spiniform squama and a broad shallow gland prominence. The median pair of processes beyond the third pair of lobes very broad, shallow, with the margin serrated, and bearing a large gland opening; margin beyond the sixth process projecting and bearing a gland orifice. Spines in the usual positions. Submarginally on either side of median line are six pairs of large tubular glands; dorsal gland openings numerous. Circumgenital pores in five groups with the formula 9:12:8:11:8. Total length 1.6 mm.; breadth 1 mm.

NEW ZEALAND: Wellington, Day's Bay, on *Freycinetia banksi* (Dr. G. A. K. Marshall).

Resembles *L. unguata*, Green, in the presence of the ungulate marginal abdominal processes, but otherwise amply distinct.

Lepidosaphes diplasia, sp. n. (fig. 15).

Scale snowy white, more or less straight, narrow in front, widening very gradually posteriorly, rather convex; larval exuviae varying from pale brown or slightly orange to dark brown through an admixture of extraneous matter from the stem of the plant.

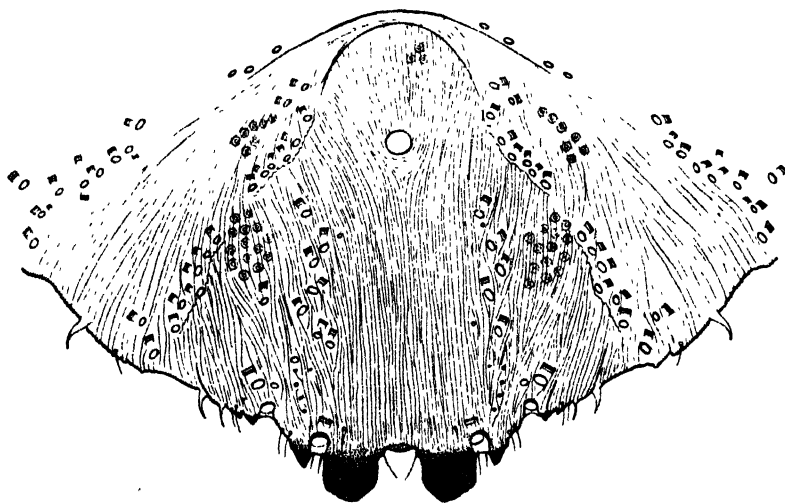


Fig. 15. *Lepidosaphes diplasia*, Laing, sp. n., pygidium of adult ♀.

Adult ♀ longish ovate, rather narrow in front, widening out gradually posteriorly till the greatest width is reached at a distance of two-thirds the length; greatest width from 2 to 2½ times length. Antennal tubercle with one very long curved seta. Anterior spiracles situated at the same level as apex of rostrum with from three to four parastigmatic pores at anterior outer angle; posterior spiracles without parastigmatic pores. Dorsal gland pores numerous, especially on marginal area, and reach forward to midway between anterior and posterior spiracles. Slightly posterior to anterior spiracles and lying on either side of ventral middle line are

two groups of small, sharp-pointed tubercles. Pygidium with median lobes very prominent, separated by a distance subequal to breadth of a single lobe basally parallel-sided with apex rather flat or very low conical and serrated; second pair of lobes consisting of conical projections; a third pair of lobes represented by a very low and often inconspicuous bicuspid projection; the usual spiniform setae present; a spiniform squama in the first and second intervals and one beyond the bicuspid projection. Circumgenital pores in five groups according to the formula 14:6:2-3:5:12. Two marginal gland orifices situated one above the other in the first and second intervals. Dorsal gland pores of first series usually asymmetrical, from five to seven in number, in second series the posterior and anterior vary from five to eight, the third series with the posterior from six to eight, and the anterior more scattered of from four to six. Length 1.2 mm.; breadth 0.5 to 0.6 mm.

TANGANYIKA TERRITORY: Nzuki, Tabora Area, on bark of "Mzagazi" (*A. H. Ritchie*).

Near to *L. machili*, Mask., but that species has the puparium dark brown.

NEW CURCULIONIDAE ATTACKING CULTIVATED PLANTS (COL.).

By GUY A. K. MARSHALL, C.M.G., D.Sc., F.R.S.

(PLATE I.)

Subfamily OTIORRHYNCHINA.

Protostrophus edax, sp. n. (Plate i, fig. 1).

♀. Integument black, densely squamose dorsally; the head brown, but pale round the eyes and beneath; the prothorax brown (with a slight coppery reflection) and with an ill-defined broad sinuate pale stripe on each side, adjoined externally at the base by a very indefinite blackish patch, and another very vague pale stripe on the extreme dorsal margin, the pleurae with thinner scaling, which is blackish on the upper half and grey below; the elytra brown, usually more or less heavily mottled with black and grey, but interval 1 always brown with a strong coppery reflection, the extreme base of intervals 1 and 4 blackish, that of intervals 2 and 3 and 6 and 7 grey, interval 3 with a conspicuous small black-ringed whitish spot near the top of the declivity, interval 7 mainly grey, and the lateral area below it thinly clothed with black scales and scattered grey ones; the lower surface rather more thinly covered than the dorsum with grey scales having a coppery reflection.

Head with very shallow punctation, hidden by the scaling and the subrecumbent flattened setae; the forehead flat or slightly depressed in the middle, with a broad deep median furrow extending back to the level of the hind margin of the eyes, which are very convex, broadly rounded behind and deepest far behind the middle. *Rostrum* separated from the head by a curved furrow, which is broad and very deep in the middle and partly hidden by the scaling laterally, about as long (with the mandibles) as the basal width and with the sides feebly sinuate; the dorsum with a transverse depression in the middle, a low median carina in the basal half, and an inwardly oblique obtuse squamose ridge on each side running from the lateral margin above the antenna to the base nearly midway between the median carina and the side. *Antennae* piceous, the funicle with the two basal joints equal, 3 slightly longer than 4, 4-6 moniliform and as long as broad, 7 broader. *Prothorax* transverse (3:2), strongly rounded at the sides, widest at the middle, distinctly constricted at the apex, so that the apical margin forms a ridge behind the eyes, truncate at both base and apex, which are of equal width; the dorsum convex transversely and almost flat longitudinally, with shallow confluent punctation (hidden by scaling) and a sharply defined narrow bare median carina from the base nearly to the apex; the scales subcircular, contiguous and finely striolate; the setae flattened, subrecumbent and longer in the middle than at the sides. *Elytra* ovate, widest before the middle, very shallowly sinuate at the base, sloping at the shoulders but there much broader than the base of the prothorax, and obtusely acuminate at the apex; when the scaling is intact the striae are practically obliterated, the punctures appearing very small, separated by the length of two or three scales, and each containing a minute horizontal seta; the intervals each with a fairly regular row (rarely duplicated) of subrecumbent setae, the apex of the seta usually reaching the base of the next behind it; the scales similar to those on the pronotum, but rather smaller. *Legs* with brownish grey scaling, the femora with an interrupted paler ring towards the apex; the front tibiae with an apical row of short, stout, dark spines extending on to the external edge; the hind corbels bare internally, broadly marginate externally at the apex and edged with a row of long stout spines.

Length, 5.5-4 mm.; *breadth*, 2.4-2.5 mm.

TRANSVAAL: White River, xi. 1924, 5 specimens.

Forwarded by the Division of Entomology, Pretoria, and reported as injurious to seedling cotton.

Protoctrophus lugubris, sp. n. (Plate i, fig. 2).

♀. Integument black, densely squamose; the head and rostrum with mingled grey and brown scales; the prothorax grey, with a very indefinite broad median darker stripe, a rather more definite stripe on each side (opposite interval 4 of the elytra) from the base to beyond the middle, and a still more distinct dark stripe on the pleurae having its upper edge on a line with stria 7; the elytra dark brown, with some indefinite grey markings across the base between striae 1 and 3 and at the external angles, with a few faint greyish flecks in the striae, and with the lateral margins grey mottled with brown.

Form elongate. *Head* with forehead flattened, closely and shallowly punctate (hidden by scaling), with scattered large punctures each bearing a stout recumbent seta, and with a deep median furrow that does not extend so far backwards as do the eyes; the anterior transverse furrow rather broad and strongly curved; the eyes much produced backwards but not reaching the prothorax, strongly convex, deepest far behind the middle, rather broadly rounded behind (as seen directly from above), and with a row of erect setae along the inner margin. *Rostrum* much shorter than its basal width and with the sides gently sinuate; the dorsum flat, with a shallow median depression in the apical half containing a feeble longitudinal carina that is almost concealed by the scales, the punctation and scaling like that of the head. *Antennae* with joint 1 of the funicle distinctly longer than 2, joint 3 longer than 4, and both longer than broad, 5 and 6 equal and as long as broad, 7 broader and slightly transverse. *Prothorax* transverse (4:3), rounded at the sides, widest in front of the middle, feebly constricted at base and apex; the base arcuate and feebly marginate, the apex scarcely narrower than the base, truncate dorsally and with a juxtamarginal carina laterally behind the eyes; the dorsum strongly convex transversely and flat longitudinally, quite even and with only a faint narrow median carina, sculptured like the head, but the setigerous punctures larger; the stout flattened subrecumbent setae all lying obliquely backwards. *Elytra* subelliptical, jointly sinuate at the base and there somewhat wider than the base of the prothorax, gradually widening from the base to the middle and obtusely acuminate behind; the striae shallow but distinct, with separated punctures visible through the scaling and each containing a minute seta; the intervals broad, slightly convex and each with a row of obliquely raised flattened setae, those on interval 1 being partly duplicated or irregular; the scales very small, smaller than those on the pronotum, subcircular or broadly ovate, and closely juxtaposed. *Legs* densely squamose; the apical spines on the front tibiae small and inconspicuous; the hind tibiae with the corbels bare.

Length, 4.8-6 mm.; *breadth* 2-2.5 mm.

NATAL: Esperanza, xi. 1924.

Described from six specimens forwarded by the Division of Entomology, Pretoria, with the information that the species is reputed to be injurious to cotton seedlings.

In general facies most nearly resembling *P. barbifrons*, Fhs., but that species differs, *inter alia*, in having a prominence in the middle of the forehead, a strong median carina on the pronotum, and the fourth tarsal joint is unusually long.

Protoctrophus mutator, sp. n. (Plate i, fig. 3).

♂♀. Integument black or piceous, with dense scaling; the head brown, with a grey stripe along the inner margin of each eye; the prothorax brown, with a broad grey stripe on each side of the disk (continuous with the cephalic stripe), the pleurae grey with a brown stripe a little below the level of the eye; the elytra very variable

in colour : sometimes almost uniformly brown, with a small indefinite dark brown patch at the scutellum ; or with an additional small indefinite dark spot at the base of interval 4, some vague dark markings on interval 2, and a rounded grey spot near the top of the declivity on interval 3 ; or with the intervals beyond stria 2 more or less suffused with grey, thus contrasting with the sutural area, and sometimes a distinct grey stripe on interval 3 and a much less distinct one on interval 5 ; the lower surface and the inflexed margins of the elytra brownish grey.

Head separated from the rostrum by a curved furrow which is almost concealed by the scaling ; the forehead flat, but sloping slightly downwards near the eyes, with a deep median furrow extending backwards a little beyond the eyes, which are not very strongly produced backwards and there rather obtuse, very convex and with the greatest depth behind the middle. *Rostrum* (excluding mandibles) much shorter than its basal width, with the sides gently sinuate ; the dorsum almost flat, with a very shallow median impression in the apical half and without any carina. *Antennae* testaceous brown, the funicle with joint 1 nearly as long as 2+3+4, joints 4-7 subequal in length and slightly transverse, 7 rather broader than the rest. *Prothorax* transverse (10 : 7), strongly rounded at the sides, widest at the middle and shallowly constricted at the apex ; the base gently arcuate and not wider than the apex, which is truncate, and not sinuate behind the eyes ; the dorsum strongly convex transversely in ♀, rather less so in ♂, and almost flat longitudinally, smooth, with the punctation quite hidden by the scaling and with a narrow, bare median line that does not quite reach the apex ; the setae quite recumbent. *Elytra* broadly ovate, jointly and shallowly sinuate at the base, with the shoulders markedly prominent and broadly rounded in the ♀, less so in the ♂, only slightly rounded at the sides in the ♀, more so in the ♂, distinctly more convex transversely in the ♀ than in the ♂ ; the striae hardly perceptible through the scaling, the shallow punctures concealed but recognisable by the small scale in the middle of each, the striae near the suture curving outwards at the base ; the intervals broad and flat, with rather numerous irregular flattened recumbent setae ; the scales small, subcircular or broadly ovate, very closely placed but scarcely overlapping, slightly smaller than those on the pronotum. *Legs* black or piceous, densely squamose ; the apical row of spines on the front tibiae inconspicuous and none on the outer edge, the hind corbels bare. *Venter* of ♂ broadly impressed at the base.

Length, 3-3.9 mm. ; *breadth*, 1.5-2 mm.

CAPE PROVINCE : Somerset East, x. 1924.

Described from 10 specimens received from the Division of Entomology, Pretoria. The insects are reported as being injurious to beans.

Very closely allied to *P. obliquecinctus*, Boh., but in that species the elytra have a pale stripe from the shoulder to the middle, then bending obliquely inwards to the suture ; the rostrum is longer and is separated from the forehead by a very shallow depression in which lies the sulcus, concealed by scaling ; the pedicels of the eyes are more prominent, and the eyes themselves are much more convex and more obtusely rounded behind ; and the shoulders of the elytra are not prominent.

Protostrophus vorax, sp. n. (Plate i, fig. 4).

♀. Integument black or piceous, densely squamose, the colouring of the scaling variable ; rarely the whole dorsum is uniform fawn colour with a coppery reflection, but the prothorax has nearly always an ill-defined paler stripe on each side of the disk and along the dorso-lateral margins ; the elytra often more or less heavily mottled with darker brown on the disk, usually leaving a very irregular and variable paler stripe in continuation of each of those on the pronotum ; the lower surface grey.

Head with the forehead almost flat and quite smooth, the sculpture being entirely hidden by the scaling except the median sulcus; the setae small, squamiform and subrecumbent; the eyes nearly round, strongly convex, deepest behind the middle, and only shortly produced backwards; the anterior delimiting furrow strongly curved. *Rostrum* (with mandibles) shorter than the basal width (3:4) and slightly sinuate at the sides; the dorsum with a rounded median depression in the anterior half and a feeble squamose median ridge towards the base, the basal lateral areas sloping gently outwards. *Antennae* red-brown, with the club paler, the funicle with joint 1 about twice as long as 2, 3-6 subequal and about as long as broad, 7 slightly longer and broader. *Prothorax* transverse (3:2), widest at the projecting rectangular basal angles (and there wider than the base of the elytra) and narrowing very slightly to the middle, thence narrowing more rapidly to quite near the apex and there very abruptly constricted so as to form a distinct angle (almost a right angle); the basal margin broadly arcuate and deeply sinuate on each side for the reception of the strongly projecting basal angles, the apical margin distinctly narrower and more gently arcuate; the dorsum very strongly convex transversely, quite smooth and even, and with a very short median furrow in the basal half but not reaching the base; the scales unequal in size, irregular in shape, and very closely placed; the setae short, spatulate and subrecumbent. *Elytra* obovate, moderately rounded at the sides, widest behind the middle, broadly rounded behind, markedly constricted at the base, and with the basal angles projecting sharply forwards and outwards; the shallow striae partly obscured by the scaling, the three juxta-sutural ones curving outwards basally, 3 and 4 almost uniting at the base; the punctures (when the scaling is intact) small but distinct, each containing a minute horizontal seta; the intervals broad and flat, each with an approximately regular row of short curved spatulate setae. *Legs* piceous, with dense uniform pale scaling and white squamiform setae; the apical row of spines on the front tibiae short but fairly stout and rather widely spaced, the hind corbels bare or with only one or two scales and narrowly enclosed and spinose externally at the apex.

Length, 3.9-4.5 mm.; *breadth*, 1.8-2.1 mm.

TRANSVAAL: Rustenburg, 26. xii. 1923, 2♂♂, 8♀♀.

Received from the Division of Entomology, Pretoria, with the information that the adults were attacking young cotton plants.

Closely allied to *P. (Strophosomus) funestus*, Pér. (1908), which I have seen only from the neighbourhood of Pretoria. The latter is a larger and proportionately broader species, with the elytra much less narrowed towards the base and the basal angles less prominent; the eyes are elongate, less convex, deepest at the middle, strongly produced backwards and with the orbit projecting on the posterior edge; the prothorax is much more transverse (2:1) and the sinuations at the anterior angles are as deep and wide as those at the posterior ones. Mr. C. W. Howard recorded *P. funestus* as doing injury to cotton and tobacco.

Protostrophus rotundus, sp. n. (Plate i, fig. 6).

♂. Integument black, densely clothed with grey scaling; the pronotum with scattered brownish scales, sometimes forming a very indefinite broad median darker stripe; the elytra sometimes with indefinite brownish spots along the striae.

Head with the forehead flattened, coarsely but shallowly punctate, with a moderately deep median furrow and three shallow sulci on each side which are almost entirely concealed by the scaling; the eyes very elongate, much less convex than usual and deepest at the middle, very strongly produced backwards, distinctly exceeding the margin of the prothorax and sharply acuminate behind, but the orbital margin not projecting. *Rostrum* (with mandibles) nearly as long as its basal width

and shallowly sinuate at the sides; the dorsum flat, with a complete bare well-marked median carina and an obtuse costa on each side of it, which is punctate and squamose and bears numerous stout brownish subrecumbent setae, as does also the lateral margin; the delimiting transverse basal furrow straight. *Antennae* piceous, the funicle with joint 1 half as long again as 2, 3 longer than 4, 4 and 5 equal and about as long as broad, 6 much broader and 7 broader still. *Prothorax* slightly more than twice as broad as long, very strongly rounded at the sides or even sub-angulate, widest well behind the middle and constricted at the apex, which is much narrower than the base; the basal margin broadly arcuate, with its external angles completely rounded off, the apex shallowly sinuate in the middle; the dorsum strongly convex transversely, with dense shallow subconfluent punctation (mostly hidden by the scaling) and a well-defined bare narrow median carina from the base nearly to the apex; the scales large, almost circular, fairly closely set, but not entirely concealing the integument; the numerous setae rather long, stout, subrecumbent and brownish. *Elytra* rotund, markedly flattened (probably more convex in ♀), the width almost or quite equal to the length at the suture, sloping obliquely at the shoulders and very broadly rounded behind, the basal margin being deeply sinuate; the striae shallow but distinct, the punctures partly hidden by the scaling, but visible and each containing a horizontal scale-like seta; the intervals with numerous irregular subrecumbent stout brownish setae. *Legs* very stout, with dense grey scaling, and the femora with long erect setae on the lower surface; the front tibiae with an apical row of stout spines (as seen from above) and three longer spines near the apex on the lower surface, the hind corbels narrowly enclosed and spinose externally and densely squamose inside.

Length, 5.4-6.3 mm.; *breadth*, 3.5-3.9 mm.

TRANSVAAL: (no exact locality), xii. 1924. 3♂♂.

Forwarded by the Division of Entomology, Pretoria, with the information that this species had completely destroyed 200 acres of maize and 50 acres of sorghum.

The nearest ally of this insect is *P. planatus*, Mshl. (Bull. Ent. Res. x, 1920, p. 273, pl. xix, fig. 4), which, however, differs in being even more flattened and the elytra much more elongate and obtusely pointed behind; the setae are small, scale-like and inconspicuous; the eyes are much shorter, more convex, deepest behind the middle and rounded behind; the femora lack the long setae beneath, etc.

***Mecostylus acuminatus*, sp. n. (text-fig. 1).**

♂♀. Dull piceous black, with the prothorax, head and the basal three-fourths of the femora red-brown; the upper side entirely bare, the lower surface thinly clothed with small grey scales.

Head with fairly close shallow punctures, those in the middle elongate and subconfluent, the forehead with a deep median fovea; the eyes strongly convex and with a deep sulcus along the inner margin. *Rostrum* much longer than broad, as long as the pronotum, parallel-sided in the basal fifth and thence gradually dilated to the apex, the basal furrow separating it from the head interrupted in the middle; the median area almost parallel-sided, coarsely punctate throughout, shallowly impressed in the anterior half, the lateral margins being there obtusely costate, and with a very indefinite depressed median carina; the inter-antennal area slightly sloping, shallowly impressed and feebly punctate, with the apical angles turned shortly upwards; the lateral areas rugose and with a broad shallow furrow above the scrobe. *Antennae* elongate, with the scape comparatively slender, cylindrical, shortly clavate, thinly clothed with short pale hair-like scales and with short subrecumbent setae; the funicle similarly clothed, the joints in order of length: 2, 1, 3, 4, (5, 6, 7), all much longer than broad; the club elongate and sharply acuminate. *Prothorax* transverse,

strongly rounded at the sides, widest before the middle, truncate at base and apex, and shallowly constricted near both; the dorsum even and set throughout with fine confluent punctures, which become more feeble laterally, the pleurae bearing numerous curved striae. *Elytra* ovate, strongly rounded at the sides, broadest before the middle and narrowing rapidly behind in ♂, less rapidly narrowed in ♀ but with the actual apex more pointed; the basal margin a little wider than that of the prothorax and shallowly sinuate, the apices jointly rounded; the whole surface finely but strongly wrinkled transversely and with ten regular rows of small deep punctures, the intervals being flat and without perceptible setae. *Legs* elongate, very thinly clothed with minute appressed pale setae, except on the lower face of the tibiae, where the setae are much longer and denser, especially on the hind pair; the femora rather strongly clavate, rugosely punctate at the apex, elsewhere shiny and with very sparse minute punctures; the tibiae rather coarsely punctate, with a row of teeth on the internal edge, each bearing a short sharp spine; the tarsi clothed above with grey or blue-grey pubescence.

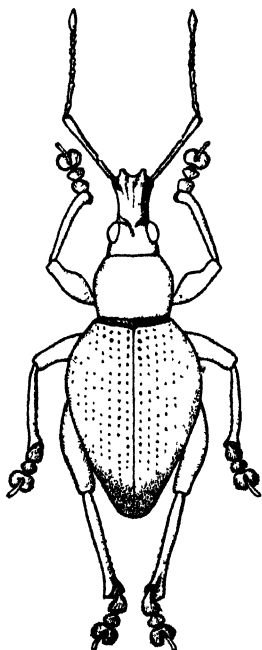


Fig. 1. *Mecostylus acuminatus*, sp. n., ♂.

Length, 15–17 mm.; *breadth*, 7.5–8.5 mm.

KENYA COLONY: Teita Hills, near Voi, 4,500 ft., xi. 1921, 3♂♂, 1♀ (*H. E. Box*).

These insects were found feeding on the leaves of coffee.

The genotype, *M. buchwaldi*, Klb. (1898), is a very different looking insect with the upper side rugosely sculptured and granulate, the striae on the disk of the elytra being quite irregular and the recesses filled with pale green scaling. The only other species, *M. (Diatmetus) vittaticollis*, Fst. (1893), is known to me by description only; it is a much smaller insect (6–8 mm. long), the pronotum being coarsely punctate, with a smooth median line in the anterior half and two discal stripes of green scaling that are continued on to the head; the elytra have the intervals transversely rugulose and subgranulate, each bearing a row of short curved setae, and are sprinkled with green scales at the base, sides and apex.

Subfamily TANYRRHYNCHINAE.

Symplezotrachelus impar, sp. n. (Plate i, fig. 5).

♀. Integument piceous, with dense grey scaling; the pronotum brownish with an indefinite pale median line; the elytra with interval 1 and the disk between striae 2 and 5 brownish (type). In a second immature specimen the pale grey scales are replaced by light metallic green and the brownish ones by coppery scales.

Head rather elongate, the distance from the eye to the pronotum almost equal to the length of the eye; the forehead almost flat, about as broad as the median dorsal area of the rostrum; the eyes broadly ovate, only slightly convex, with a row of four or five erect setae adjoining the upper margin. *Rostrum* as long as the pronotum, parallel-sided, much more strongly curved dorsally than beneath; the elevated median dorsal area parallel-sided in the anterior half and gradually dilated from the middle to the base, which lies much above the level of the forehead, with a very shallow median furrow on the apical half which becomes a short fine carina at the apex, the space between the scrobes rather greater than the width of the apex of the scape and equal to the length of joint 2 of the funicle. *Antennae* with the scape gradually widening from base to apex, densely squamose and with subrecumbent setae; the funicle with joint 1 somewhat longer than 2, 3 and 4 subequal, 5-7 shorter, subequal, moniliform and as long as broad. *Prothorax* transverse (15:11), widest at the base, gently rounded at the sides, shallowly constricted at the apex; the apical margin truncate dorsally and at the sides, two-thirds the width of the base, which is broadly arcuate; the dorsum not pulvinate, but normally convex, smooth and even, the sculpture being entirely hidden by the scaling; the scales very closely juxtaposed, the setae short, adpressed and somewhat inconspicuous. *Elytra* ovate, broadest before the middle, obtusely pointed behind, with the basal margin deeply sinuate; the narrow striae containing shallow separated punctures, stria 1 parallel with the suture at the base, striae 2 and 3 curving rather strongly outwards; the intervals broad and flat, the scales like those on the pronotum but rather more convex, and the setae very short, irregular, spatulate, recumbent and very inconspicuous. *Legs* with dense grey scaling, all the tibiae with a fringe of rather long setae on the lower edge.

Length, 4.8-5.4 mm.; *breadth*, 2.4-2.7 mm.

NATAL: Mount Edgcumbe, 27. iii. 1923, 2♀♀.

Forwarded by the Division of Entomology, Pretoria, with the information that the adults were found on the leaves of sugar-cane.

This species may be distinguished from all its congeners by the fact that joint 1 of the funicle is longer than 2, and the posterior coxae touch the margin of the elytra. It is most nearly related to *S. inaeffectatus*, Boh., but that species is much smaller, the base of the rostrum is not higher than the forehead, the eyes are quite flat and almost circular, and striae 2 and 3 on the elytra are not curved outwards at the base.

Subfamily ERIRRHININAE.

Echinocnemus oryzae, sp. n. (text-fig. 2).

♂. Integument black or piceous, densely clothed with chalky grey scales throughout, but the dorsum often more or less suffused with fawn-colour; in the darker specimens there is always a pale spot behind the middle of the elytra on interval 3.

Head with the forehead markedly flattened or slightly depressed. *Rostrum* as long as the pronotum, gradually narrowing from the base for a short distance, then parallel-sided to near the antennae (inserted at one-third from the apex), thence strongly dilated to the apex, bare above and below except for some scaling near the base, closely and strongly punctate near the base, but the punctures becoming rapidly much finer to the middle and almost or completely disappearing on the

glabrous shiny apical half ; the scrobes not extending anteriorly beyond the antennae. *Antennae* honey-brown, the scape bare except for a few setae at its apex ; the funicle with dense minute whitish scales, joint 1 as long as 2+3+4 and much thicker. *Prothorax* somewhat transverse (6:5), truncate at the base, with the basal angles broadly rounded, subparallel-sided from near the base to beyond the middle and thence roundly narrowed at the apex ; the dorsum flatly convex, quite smooth and densely squamose, the small transverse white setae being discernible only with

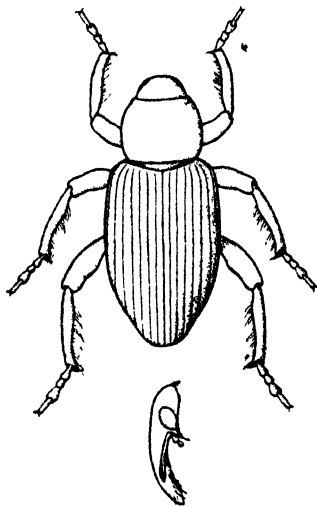


Fig. 2. *Echinocnemus oryzae*, sp. n., ♂.

difficulty. *Scutellum* bearing short erect scales (often abraded). *Elytra* shallowly sinuate at the base, with the shoulders prominent and roundly rectangular, parallel-sided from there to far beyond the middle and obtusely acuminate at the apex, with a very shallow transverse depression at the base extending on each side to stria 3 and a feeble pre-apical impression on each elytron ; the striae fine and impunctate, the intervals broad and almost flat, each bearing an irregular row of recumbent transparent setae that are very easily overlooked ; the scales nearly circular, slightly overlapping and having a fine silky surface. *Legs* piceous, with dense chalky-grey scaling ; all the tibiae with a row of stout teeth along the inner edge, these being partly concealed by a fringe of long white setae. *Venter* of ♂ with a broad median impression on the terminal ventrite bearing a long erect seta on each side of its apical margin.

Length, 4.5–6 mm. ; *breadth*, 1.8–2.4 mm.

MADRAS : Kaikalur, Krishna District, viii.–ix. 1915 (T. V. Ramakrishna) ; Samalkot, vii. 1922 ; Thurumella, Guntur District, ii. 1925 (Y. Ramachandra Rao).

This insect differs from all the previously described Indian species in the form of the rostrum ; in the latter it is shorter and much thicker, cylindrical, and closely punctate and densely squamose throughout ; the tibiae are also less deeply sinuate internally in the new species and the teeth are distinctly longer.

Described from 12 specimens forwarded by Rao Sahib Y. Ramachandra Rao, who writes as follows :—"The grubs are of small or medium size, about a quarter of an inch in length, and of a spotless translucent white colour. They appear to be fitted to a semi-aquatic existence and are found clinging to and feeding on the rootlets of paddy in the mire of a rice-field. Plants attacked are reported to become stunted and do not put forth tillers as usual."

Subfamily ANTHONOMINAE.

Anthonomus cyprius, sp. n.

♂♀. Piceous brown (♂) or red-brown (♀), with stripes and bands of narrowly lanceolate or setiform pale scales; the pronotum of ♂ with a narrow median and a broad lateral stripe of rather dense white scales on each side, the lateral stripes being golden, instead of white, in ♀; the scutellum with dense white scaling; the elytra with sparse black recumbent setae along the intervals, a rhomboidal common patch of rather sparse white scales on the basal half (the anterior angle touching the scutellum, the posterior attaining about the middle of the suture, and the lateral ones reaching stria 5—more indefinite in ♂), a comparatively narrow transverse white band behind the middle (narrowest on interval 4, widening towards the suture and more so externally, the scales on intervals 2 and 3 being usually golden yellow), an apical white patch emitting a short stripe backwards on the apex of interval 4, interval 1 from the transverse band to the apex and the lateral margin (except the basal fourth) clothed with white scales, and a small patch of thin white (♂) or golden (♀) scales on the shoulders; the markings less defined on ♂ owing to additional scattered white scales; the lower surface with rather sparse stout recumbent white setae.

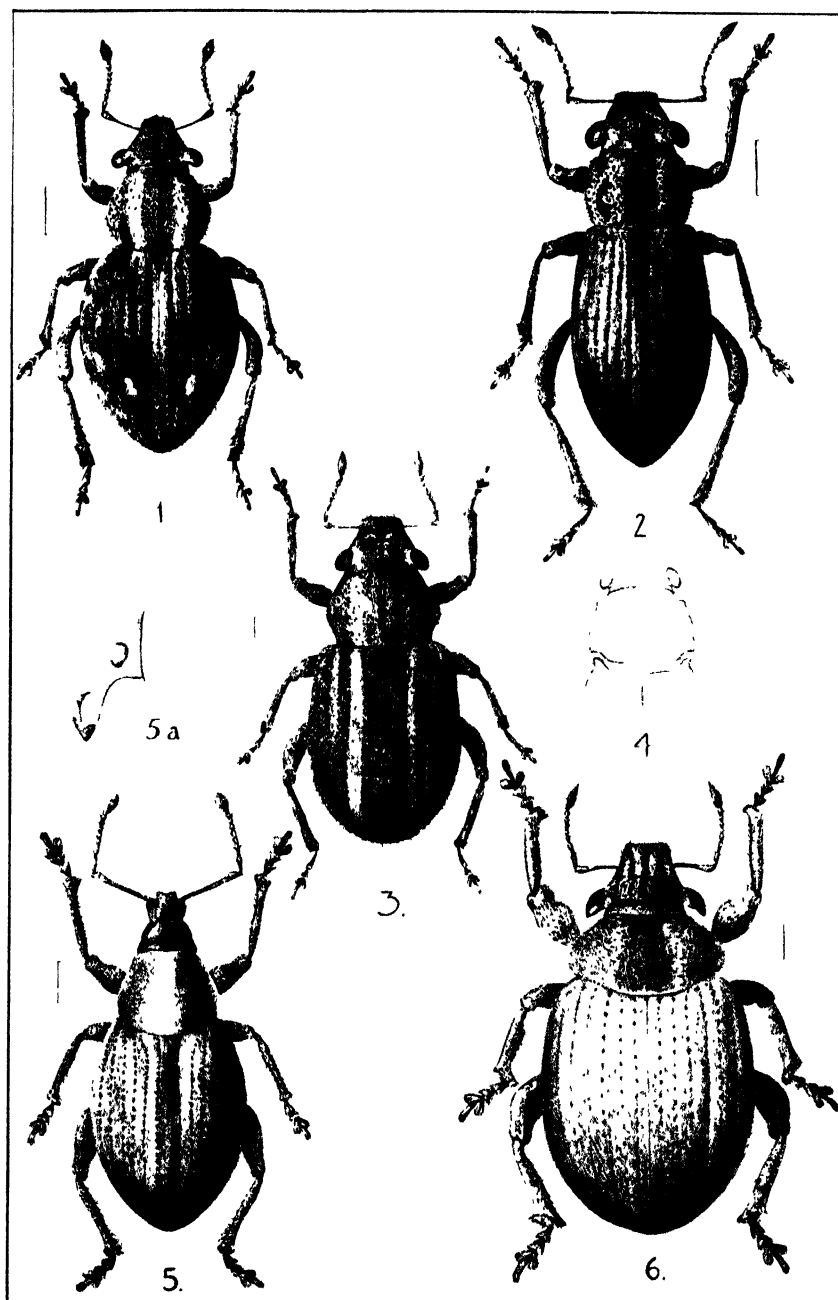
Head with very sparse yellowish setae and a dense median white stripe; the forehead depressed, with a small deep median fovea, and a fringe of white setae along each eye; the eyes rather prominent, more so than in *A. ornatus*, Rch. *Rostrum* as long as (♂) or longer than (♀, 5:4) the head and pronotum, gently curved and very gradually widening from base to apex; very closely and rugulose punctate in ♂, much more finely and sparsely so in ♀, without any lateral carinae in the basal half, and the scrobes not continued anteriorly beyond the antennae. *Antennae* honey-brown, with the club infuscated; the funicle with only six joints, joint 1 as long as 2+3, 3 slightly longer than broad, 4-6 moniliform and more or less transverse. *Prothorax* transverse, moderately rounded at the sides, widest near the base, and shallowly constricted at the apex; the dorsum closely and strongly punctate, without any smooth median line; the spaces between the longitudinal stripes of scales sparsely covered with yellowish and black setae, the latter being more obvious in the ♀. *Scutellum* much longer than broad. *Elytra* widest far behind the middle, with the shoulders moderately prominent, strongly punctate-striate, with the intervals almost flat and feebly rugulose. *Legs* uniformly reddish yellow in ♀, the apical half of the femora and basal half of the tibiae brown in ♂; the tooth of the front femora small, much shorter than the width of the tibia and with its anterior edge sinuate, the teeth on the posterior pairs smaller but distinct; the front tibiae with the inner edge not convex in the middle in ♀ and very feebly so in ♂, the hind pair with a distinct apical mucro; the claws simple and divaricate.

Length, 2.7-3.3 mm.; *breadth* 1.2-1.6 mm.

CYPRUS: iv. 1925 (*D. S. Wilkinson*).

Described from 3 ♂♂ and 7 ♀♀ bred by Mr. Wilkinson, Government Entomologist, from buds of peach trees.

This species may be distinguished from any of the previously described Palaearctic forms by its 6-jointed funicle and simple claws (like those of *varians*, Payk.). Superficially it most resembles *A. ornatus*, Rch., in which the sexes differ in ground-colour in the same way; but the latter is a larger insect and has the scales much narrower, setiform and not lanceolate; the median stripe on the pronotum is markedly dilated in the middle, and the lateral stripes are thinly setose; the scutellum is much broader, as is also the transverse band on the elytra.



NEW SOUTH AFRICAN CURCULIONIDAE.

- | | |
|---------------------------------------|--|
| 1. <i>Protostrophus edax</i> , sp. n. | 4. <i>Protostrophus vorax</i> , sp. n. |
| 2. " <i>lugubris</i> , sp. n. | 5. 5a, <i>Sympiezorrhynchus impar</i> , sp. n. |
| 3. " <i>mutator</i> , sp. n. | 6. <i>Protostrophus rotundus</i> , sp. n. |

THE HISPID LEAF-MINER (*COELAENOMENODERA ELAEIDIS*, MAUL.)
OF OIL PALMS (*ELAEIS GUINEENSIS*, JACQ.) ON THE
GOLD COAST.

By G. S. COTTERELL,
Entomologist, Gold Coast.

Oil palms in parts of the oil palm belt in the Gold Coast Colony have suffered at intervals from the attacks of a leaf-mining beetle. Specimens of the adult beetle and full-grown larva were sent by Mr. W. H. Patterson, Government Entomologist to the Gold Coast, to the Imperial Bureau of Entomology in 1920. These were determined by Mr. S. Maulik as a new species of the genus *Coelaenomenodera* (family HISPIDAE) and described under the specific name *elaeidis* (Bull. Ent. Res., x, p. 171). This species is indigenous to the West Coast of Africa, and hitherto has not been recorded outside the Gold Coast, but no doubt occurs throughout the West Coast oil palm belt. According to Mr. Maulik, 32 species of this genus are known, of which four only are recorded from Africa, the remainder being from Madagascar.

C. elaeidis is similar in habits to *Promecotheca opacicollis* and *P. cumingi*, which occur in Fiji, the Phillipines and the New Hebrides, and mine in coconut foliage. The pest was first recorded in the Gold Coast in 1909-1910 (Ann. Rept. Agric. Dept. Gold Coast, 1909-1910) as defoliating palms in the Eastern Province of the Colony to a large extent. It was stated to have been checked by the advent of the following rainy season. Again in 1919 it was reported as a pest and again as being checked by the following rainy season.

The present attack commenced at the beginning of the rains, *i.e.*, July, and was confined to a small area on the western slopes and top of the Akwapim ridge in the Eastern Province, a range of hills running N.N.E. from the coast and varying from 800 ft. to 1,500 ft. in height. The beetle was also noticed in considerable numbers in a small area on a large oil palm estate in the Western Province, where the country is more or less flat. This latter attack, however, was soon checked by natural means, and did not cause much damage. The former attack lasted until January 1924, when it also was checked by natural means.

The oil palm belt occurs near the coast and extends about 100 miles inland. It is particularly dense in parts of the Eastern Province and in the Western Province. The palm is not cultivated, but the natives collect the fruit from the trees in the forest, bringing them in to extract the oil. However, the cocoa industry, which has flourished remarkably in the last twenty years, has practically supplanted the oil palm industry, which is only carried on by the natives in a few areas in a very small way. There are a few European concessions in the Western Province, but here again the palm is not cultivated, the fruit being brought into buying centres by the local inhabitants and by labourers employed. Cultivation would hardly be possible, considering the large collecting area and the cost of local labour. This indicates that an artificial control is almost impossible.

Palms of all ages are attacked, except those under three or four years old. The leaflets are attacked soon after they have unfurled, the larvae mining under the epidermis. As many as ten mines per leaflet have been observed, and these mines may cover a considerable area, depending on the number of larvae in each mine. Mines have been observed containing five larvae, which when full-grown have eaten out an area in the parenchyma of the leaflet up to nine inches long and one inch wide. This area turns brown, resembling a large blister. The leaflets are rapidly eaten away and stripped to the mid-rib by the action of wind, a badly attacked palm having the

appearance of the after-effects of fire. This naturally causes a falling off in the yield of palm bunches and devitalisation of the tree. No records are available at present to show to what extent this occurs.

Other food-plants of the larvae are coconuts, *Borassus* and certain ornamental palms. These are not favoured except during a bad attack on surrounding oil palms, very few larvae ever maturing, and the life-history is prolonged owing to the coarser food material. The adults feed also on these plants, and, in addition, on royal palms, and in a few cases on elephant grass. The damage caused is not so serious, but is characteristic in that the soft material between the leaf-veins is eaten, giving the appearance of longitudinal cuts along the underside of the leaf. These cuts do not penetrate the leaflet, but as only the upper epidermis is left, the leaflet is considerably weakened and consequently suffers from the effects of wind. They also allow the entrance of fungi, which are naturally prevalent in a humid atmosphere.

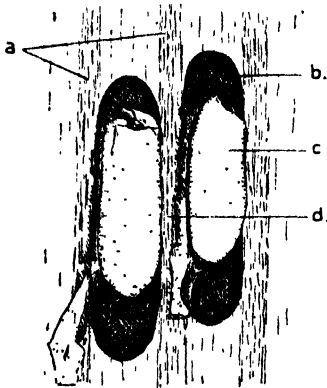


Fig. 1. Eggs of *Coelaenomenodera elaeidis*, *in situ*, after the capsule of fibre and lower epidermis of leaflet has been removed: *a*, leaf-veins; *b*, cavity dug out by female; *c*, egg; *d*, gummy substance attaching egg to side of cavity.

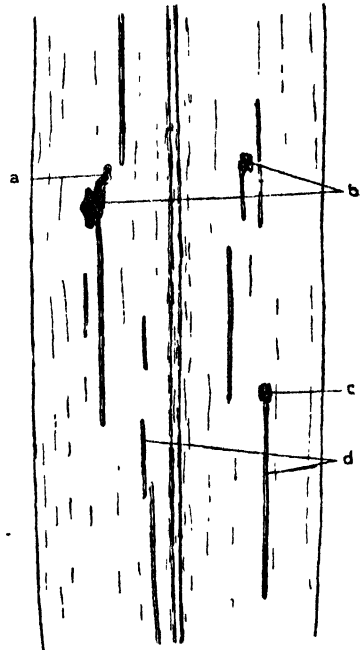


Fig. 2. Egg-masses and feeding channels of adults on lower surface of leaflet: *a*, young larva beginning to mine; *b*, *c*, egg-masses; *d*, feeding channels of adults.

The life-history of the beetle was obtained at Aburi Agricultural Station from cages on the trees. Unfortunately other work, mostly of a travelling nature, prevented a regular inspection of these.

The eggs (fig. 1) are inserted by the female in the underside of the leaflets, a cavity having previously been dug out to take each egg. They are deposited longitudinally to the leaflet and between adjacent leaf-veins. They are covered by a mass of leaf fibre, which the female regurgitates, having extracted the chlorophyll. From two to five eggs are covered by one egg-mass. Feeding channels of the adult are usually found leading up to the egg-mass, from which the female has collected the necessary fibre (fig. 2).

The egg is creamy white when first deposited, and from two to three millimetres in length. It is attached to the leaflet by a gummy substance, which resembles chitin and entirely covers the egg. The incubation period of the egg is approximately 28 days. After hatching, the larvae commence to mine either up or down the leaflet immediately under the upper epidermis, being found, as a rule, all together at one end of the mine (fig. 3). Three moults were the maximum observed. Breeding conditions made it impossible to observe actual moulting, owing to this occurring inside the leaf. Opening up of the leaf caused rapid drying up and consequent death of the younger larvae. The later larval skins are easily observed inside the mines. The larval life is from 40 to 44 days, depending on climatic conditions. The larva (fig. 4) is yellow in colour, legless and flattened, and about one centimetre in length when full-grown. It has a pair of strong stumpy jaws protruding from the slightly swollen head.



Fig. 3. Leaf-mines in different stages :
a, larvae feeding inside mine ; b, c, mines.

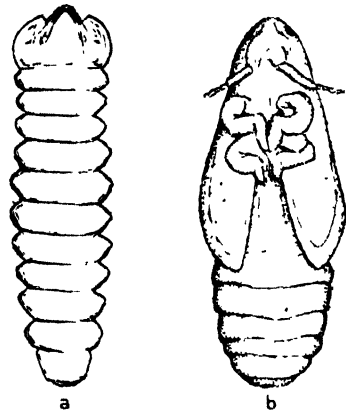


Fig. 4. *Coelaenomenodera elaeidis*, Maul. :
a, larva ; b, pupa.

Three to four days before pupation the full-grown larva ceases to feed and locates itself near the middle of the mine. The pupa (fig. 4) is dark orange in colour and capable of a small amount of movement in the mine by wriggling its abdomen. The pupal period varies from fifteen to twenty-two days. The adult beetle emerges by a splitting of the anterior end of the pupa and remains in the mine a few hours to harden before eating its way through the dead epidermis of the leaf.

The life-cycle, from the oviposition of the egg to the emergence of the adult, varies from 82 to 94 days, depending on climatic conditions and the amount of food-material. Copulation and oviposition take place three or four days after emergence, the complete life-cycle being approximately 13 to 14 weeks.

The adults feed on the lower surface of the leaflets, usually working in an upward direction. The green material between the veins is eaten, leaving brown longitudinal cuts. In no case was feeding observed on the upper surface of the leaflets. The adults are exceedingly sluggish and do not easily take to flight. On being brushed off the leaves they fall some distance before taking wing. In the early morning and evening they are still more sluggish, falling to the ground when disturbed. Copulation and oviposition take place during the heat of the day.

The attack in July was characterised by an invasion from the N.N.E., i.e., along the contour of the Akwapim ridge (fig. 5). This was followed by a second invasion

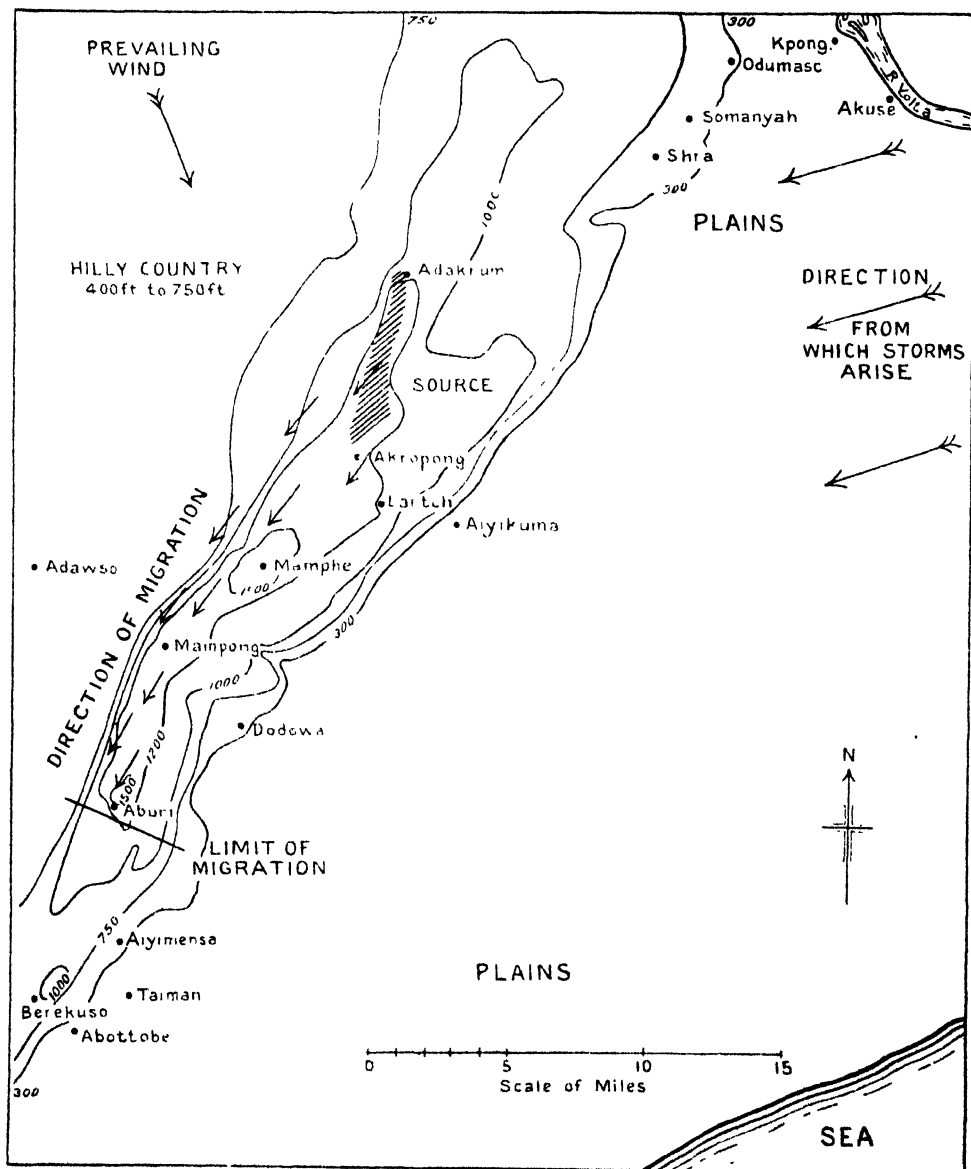


Fig. 5. Sketch-map showing the Akwapim ridge, Gold Coast, and the direction of migration of *Coelacnomenodera elaeidis*, Maul.

in October from the same direction. Both these invasions reached their southernmost limits at Aburi, and the migration only occurred along the top and western slopes of the Akwapim ridge, originating in the neighbourhood of Adakrum and Akropong, a distance of about sixteen miles.

Migration commenced at about ten in the morning on sunny days, reaching its maximum about two in the afternoon. During this time the air was thick with adults, during both migrations. Rain and cloudy weather immediately stopped flight. These migrations occurred over a period of 10 consecutive days. Palms between Adakrum and Aburi were also attacked, showing that not all the beetles reached Aburi, some settling on the way. It is probable that the second invasion consisted of adults resulting from these rather than from the place of the original infestation, as palms in the latter area showed little sign of developing larvae prior to the invasion, food material being short owing to defoliation caused by the first infestation. It has been found that a similar feature occurs with *Promecotheca opacicollis* in the New Hebrides, but on a much larger scale. Kowalski states that swarming and migration occur as soon as food material becomes short in one locality owing to previous attacks. The emerging adults then migrate a short distance and oviposit in a fresh locality; in fact, the females show an aversion to ovipositing in an already damaged tree. This is probably what occurs with *C. elaeidis*, an increase in numbers resulting in a shortage of food material and consequent migration.

The cause of the periodic increase of the beetle is unknown. Adakrum and Akropong are situated on the top of the Akwapim ridge, and therefore exposed to storms. These storms arise from the east, to which side the ridge is most exposed. As the eggs and larvae are heavily parasitised, it is presumed that the adult parasites, owing to their size, would be more severely affected by these storms than the host, giving the latter a chance to increase beyond its normal proportions. This theory has been put forward as the cause of the periodic increase in Fiji of *Promecotheca*.

There was no third invasion at Aburi, for natural enemies controlled the larvae resulting from the eggs laid by those adults which did not reach Aburi during the second invasion. There were also few emergences of adults at Aburi from the generation arising from the second invasion, parasites having overcome these. A 90 per cent. parasitisation was estimated during this generation at Aburi.

The attack mentioned as occurring in the Western Province probably originated from other causes and did not develop beyond the first generation. Here there is no high ground, and palms would not be exposed to storms to the same extent. No migration occurred in this area.

The following details of the migration of the adult beetles at Aburi are given :—

First invasion : 20th July 1923 ; finished 30th July 1923.

Oviposition commenced 22nd July ; finished approximately 5th August.

First eggs hatched 18th August ; last eggs approximately 1st September.

First larvae pupated 1st October ; last larvae pupated 14th October.

First adults emerged 20th October ; last adults emerged 4th November.

Second invasion : 15th October 1923 ; finished 25th October 1923.

Oviposition commenced 18th October ; finished approximately 1st November.

First eggs hatched 14th November ; last eggs approximately 28th November.

First larvae pupated 26th December ; last larvae pupated 9th January.

First adults emerged 16th January ; last adults emerged 30th January.

As Aburi was at the southernmost limits of the migration, it will be noticed that the next generation of adults resulting from the first invasion at Aburi did not emerge until slightly later than the commencement of the second invasion of adults, so that

oviposition would naturally cover a longer period and the resulting larvae would be in a suitable stage for parasitisation for a longer period. This was borne out by field observation of the number of larvae parasitised and by the fact that the second invasion did not appreciably increase the number of larvae.

Natural checks consist for the most part of Hymenopterous parasites. These are egg and larval parasites. Two egg parasites of the family EULOPHIDAE have been bred out. These were both new species, and have recently been described by Dr. James Waterston, of the British Museum, under the names of *Closterocerus africanus* and *Achrysocharis leptocerus* (Bull. Ent. Res., xv, pp. 392-393). The former is a minute species with dark concentric banding on the fore-wings; it was bred out only from eggs resulting from the first invasion and was not common. The *Achrysocharis* is also a minute species with yellow legs and red eyes; it was quite common, particularly in eggs of the second invasion.

Two larval parasites (also of the family EULOPHIDAE) were bred out, one attacking the young larva, the other parasitising during the latter half of larval life. The former, *Dimmockia aburiana*, Wtstn. (l.c. p. 385), emerges when its host is about half-grown. Not less than three and as many as six eggs are laid in each host. The fully developed parasite larvae emerge and pupate outside of the host, the pupae being attached to the inside of the mine by the end of the abdomen. The pupal period is approximately eight days. The adult parasites differ very much in the sexes. The male has projecting appendages from three joints of the antennae and has a white oval patch on the dorsal surface on the two proximal segments of the abdomen. The antennal joints of the female proximal to the elbow are white and the antennal appendages and oval patch on the abdomen are absent. The tibiae and tarsi of both sexes are white. The female emerges slightly later than the male. This species was bred only from larvae resulting from the first invasion. It is itself heavily parasitised by *Pleurotropis nigripes*, Wtstn. 1915 (family EULOPHIDAE), a small black species with white tibiae. In the first generation under observation only 25 per cent. of the *Dimmockia* were unparasitised. Later generations appeared to be nearly totally parasitised.

The second larval parasite, *Cotterellia podagrica*, Wtstn. (l.c. p. 388) emerges from the full-grown larva and pupa. This parasite occurs singly, pupation taking place inside the host. Both sexes are bluish black, with dark wings. The proximal joints of the tarsi are white and the femora large. The antennae of the male are hairy beyond the elbow, and the posterior borders of the abdominal segments are white. The wings are considerably darker in the female and covered with short hairs. The pupal period is from four to five weeks. The female emerges considerably later than the male, in practically all cases emerging from the pupa, whilst the male emerges from the full-grown larva, pupation taking place before pupation of the host. This species is also heavily parasitised by *Pleurotropis nigripes*.

Cotterellia podagrica was much more effective on those larvae resulting from the second invasion, and probably it and the egg-parasites, *Closterocerus africanus* and *Achrysocharis leptocerus*, are the really effective parasites, but their action is temporarily delayed first by the effects of weather conditions and then by migration of the host. Egg-masses deposited by females of the second invasion at Aburi were parasitised up to fully 50 per cent. *Dimmockia aburiana* is effective as a check for a short time after an increase of its host, but loses its effectiveness as its hyper-parasite increases in proportion.

Other natural checks are entomogenous fungi. Owing to the high humidity these are common. A few cases of the adults of *C. elaeidis* being attacked were observed, but death probably ensues too late, oviposition having been already completed some time before. Rainfall also acts as a check; heavy rain, such as occurs during October and November, floods the larger mines, drowning the larvae. Birds were not observed to feed on the adults, which are apparently distasteful.

Artificial controls are impossible in a country such as the Gold Coast. Shaking the leaves in the early morning or evening during an invasion and collecting the adults at the base might be effective, but would require a large amount of labour not to be obtained on the Gold Coast. Pruning off and burning of the lower leaves at definite periods would be effective in a small way. This would destroy the more fully grown larvae, as the larger mines would naturally be on the older leaves. A serious attack showing no sign of abating might warrant the breeding of parasites and transferring them to the area of infestation.

Owing to the high percentage of parasitism it is unlikely that this beetle will ever become a serious pest. Under ordinary conditions parasitism probably reaches as much as 90 per cent., from 50 per cent. to 60 per cent. being parasitised in the egg stage. Periodic outbreaks, such as that in 1923 and previously, may occur under conditions such as are found on the Akwapim ridge.

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THE CHERRY BLACK FLY (*MYZUS CERASI*).

By F. M. WIMSHURST, B.A. (Oxon.).

Although *Myzus cerasi* is sometimes a serious pest of the cherry, and is therefore of economic importance in Great Britain, the life-history has never been completely worked out in the Eastern Hemisphere. A good deal of work has been done upon the species in America, and the life-history is recorded by W. A. Ross¹ as it occurs on that continent.

The object of the present paper is to give a systematic description of the forms found, and an account of the life-history so far as it has been traced by the writer during two years' observation in Kent.

Synonymy.

This species was first described by Fabricius² in 1798, under the name of *Aphis cerasi*, F. The genus *Myzus* was introduced by Passerini,³ who took *A. cerasi* as his type. Kaltenbach,⁴ in 1872, described a *Myzus aparines*, and this, according to Dobrovliansky,⁵ is the summer form of *Myzus cerasi*, which is described below as occurring upon *Galium aparine*, L. In the writer's opinion, however, the synonymy of *M. aparines*, Kalt., with *M. cerasi*, F., must be left an open question. Kaltenbach certainly places the description of the two Aphids side by side, but his *M. aparines* has always been taken to be *A. rumicis*, F., and the vagueness of his description seems to warrant either view. The summer form of *M. cerasi* is certainly not "flach gerandet," and Kaltenbach makes this "flat-sidedness" an important point. On the other hand, Kaltenbach states that *M. aparines* has "die Stirnknöpfe nach innen stark vortretend (genähert)," and "porrected antennal tubercles" are a characteristic of *Myzus cerasi*.

The synonymy is therefore as follows :—

Myzus cerasi, F.

Aphis cerasi, F., Schr., Kalt., Walk., Koch, Fitch.

Ceraphis cerasi, Amyot.

Myzus cerasi, Pass., Buckt.

? *Myzus aparines*, Kalt.

Some of the forms of *Myzus cerasi* have been briefly described by Theobald,⁹ Gillette,⁷ French,¹⁰ and Buckton.¹¹

Description of Forms.

FUNDATRIX.—Average body measurements,* 2.46 mm. by 1.43 mm. *Body* oblong globose in shape, pointed posteriorly; shining black dorsally, brownish ventrally and between the segments of the thorax; hairless, and with no tubercles on thorax or abdomen. *Head* hairless; eyes compound, black, more closely set into head than in the succeeding forms; small ocular tubercle present; frontal lobes porrected. *Antennae* average 1 mm. in total length, with five segments; segment 3 pale brown, the others dusky; segment 1 about as broad as long, 0.08 mm.; 2 also as broad as long, 0.07 mm.; 3, 0.36 mm.; 4, 0.21 mm.; 5, 0.28 mm.; a few short hairs on each segment. *Sensorium* on segment 3 in some specimens; there is always one at the top of the 4th segment and a group of them on the 5th at the base of the unguis. *Thorax*: legs dusky except for the tibiae and proximal portion of the femora, which are pale brown. Short hairs on all segments but especially numerous

* Measurements are, of course, very variable. So far as possible, average measurements are given in text and actual measurements in drawings.

on the tibiae. *Abdomen*: cornicles black, 0.41 mm. long, tubular, tapering slightly at the distal end, with a decided constriction at tip, so that there is a sort of collar round the mouth of the tube. Cauda conical, black, bearing several large hairs and densely covered with bristly scales. Genital plate dusky, bearing numerous large hairs scattered over its surface, slightly crescentic in shape. Anal plate oval in shape and slightly dusky with several large spine-like hairs.

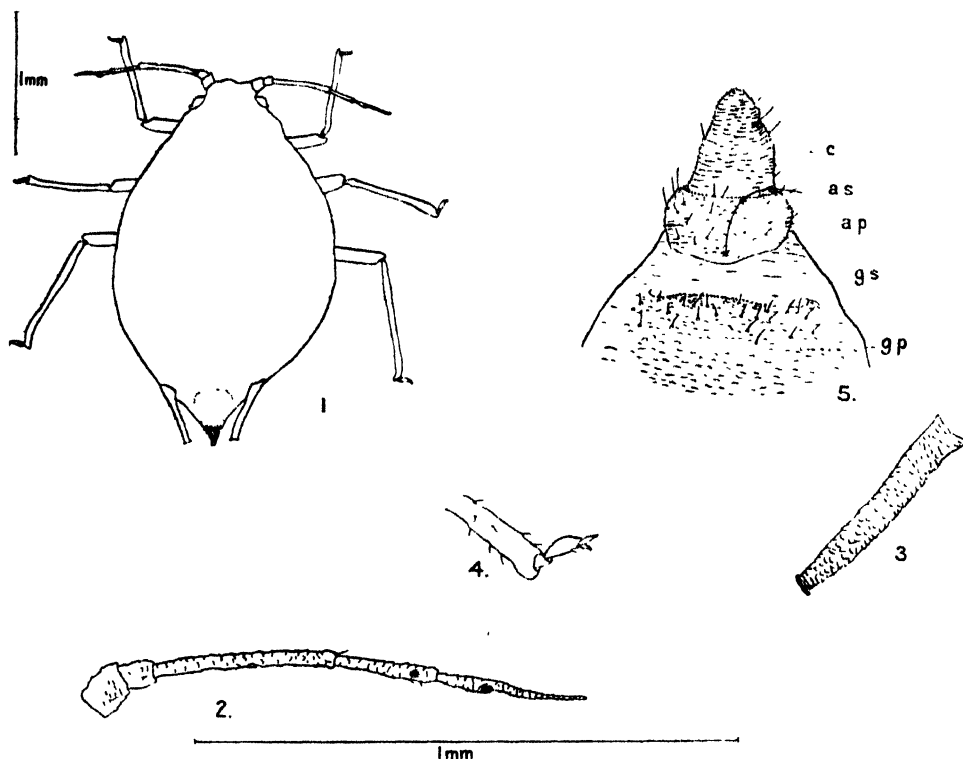


Fig. 1. *Myzus cerasi*, F., fundatrix: (1) dorsal view; (2) antenna; (3) cornicle; (4) tarsus of 3rd leg; (5) caudal apparatus, ventral view: a.s., anal slit; g.s., genital slit; a.p., anal plate; g.p., genital plate; c, cauda.

Larval life. Each aphid moults four times before it reaches maturity.

APTEROUS VIVIPAROUS FEMALE.—Body measurements, 1.96 mm. by 1.3 mm. Closely resembles the fundatrix with the exception of the antennae, which are 6-segmented and 2 mm. in length; segment 1, 0.098 mm.; 2, 0.09 mm.; 3, 0.52 mm.; 4, 0.32 mm.; 5, 0.29 mm.; 6 (including unguis), 0.469 mm.; 3 and 4 are pale, the others dusky. In some specimens there are two abdominal tubercles just posterior to the cornicles. Cornicles, 0.57 mm.; cauda, 0.16 mm. Moults four times during larval life.

WINGED VIVIPAROUS FEMALE.—Average body measurements, 2 mm. by 1 mm. *Body* elongate, with a slight constriction between thorax and abdomen. Shining black except for ventral side of abdomen, which is brownish. A few small hairs are scattered over body. Upper wing about 2.6 mm. long; stigma of wing brown. *Head* black, with a few small hairs; eyes compound, dark red; small ocular tubercle present; frontal lobes porrected and a sensorium present in the mid line between them; head separated from prothorax by a groove. *Antenna*, average length

1.7 mm., with six segments; segment 1, 0.098 mm.; 2, 0.098 mm.; 3, 0.5 mm.; 4, 0.3 mm.; 5, 0.26 mm.; 6, 0.55 mm.; 14-20 sensoria arranged in an irregular row along segment 3, one at tip of 5, and a group on 6 at base of unguis. *Thorax*: legs dusky, except for proximal portions of femora and tibiae, which are pale brown. A few hairs on femora and tarsi, numerous bristly ones on tibiae. *Abdomen*: cornicles black, 0.31 mm. long, tubular, opening out into distinct flange at end. The cauda and anal plate and, to a lesser degree, the genital plate are densely covered with bristly scales. Cauda club-shaped, turning up in tail-like fashion, with several large hairs. Genital plate oval to square, with several short stiff hairs scattered round outer margin.

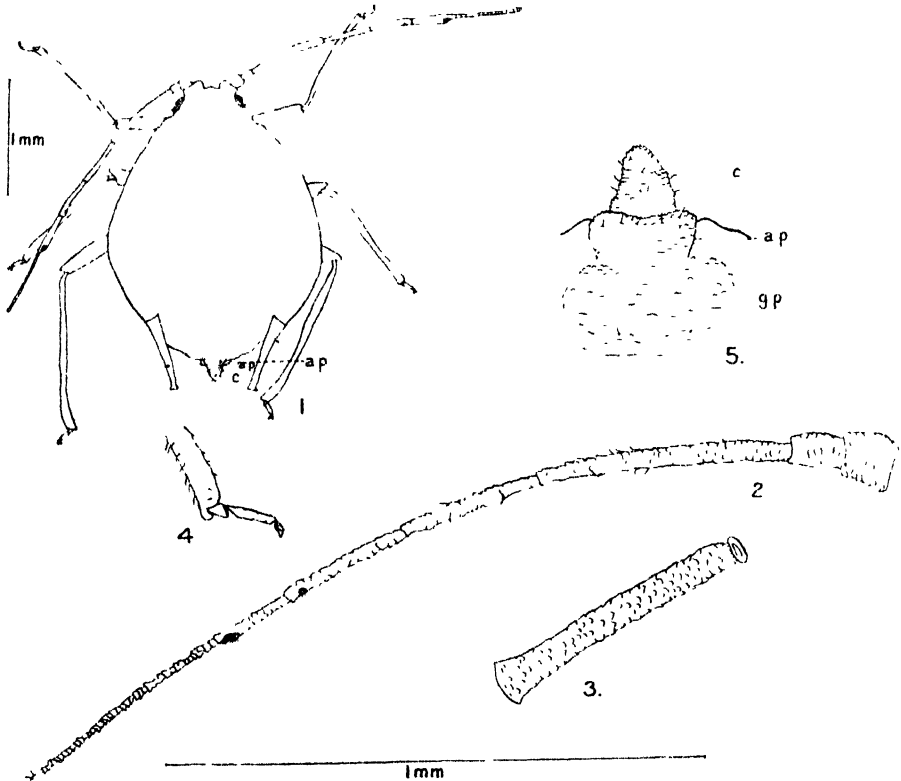


Fig. 2. *Myzus cerasi*, F., apterous viviparous ♀: (1) dorsal view; (2) antenna; (3) cornicle; (4) tarsus of 3rd leg; (5) caudal apparatus, ventral view: *a.p.*, anal plate; *g.p.*, genital plate; *c.*, cauda.

Larval life. Moults four times. Wing-cases show after second moult, and in the nymph stage (just previous to last moult) they are present as conspicuous white knobs upon the thorax.

APTEROUS VIVIPAROUS FEMALE (on *Galium*).—Body length, approximately 1.6 mm. *Body* oval, pointed posteriorly. Colour very variable; darkest brown to pale yellow, which is sometimes almost white; some specimens are a bright cinnamon, but these different forms seem to be identical in structure and may feed side by side on the same shoot. A few very small hairs are sparsely scattered over the body. *Head* dusky, with several small hairs. Eyes red, with an ocular tubercle. Frontal lobes large and porrected. Antennae with six segments; segs. 1 and 6, and distal end of 5, dusky, other segments pale; a few short hairs on all segments. Total length approximately 1 mm.; segment 1, 0.08 mm.; 2, 0.05 mm.; 3, 0.21 mm.;

4, 0.13 mm.; 5, 0.13 mm.; 6, 0.36 mm.; one sensorium at tip of segment 5, and a group on 6 at base of unguis. *Thorax*: legs pale in colour, except for tarsi and sometimes distal ends of tibiae, which are dusky. A very few short hairs on femora and tarsi, numerous bristly ones on tibiae. *Abdomen*: cornicles very dark; 0.36 mm. approximately; broad at base, but tapering towards tip and opening out into a distinct flange at end of tube; imbricated, converging towards cauda. Caudal apparatus dusky and clothed with bristly scales. Cauda conical in shape, slightly constricted just below tip, bearing a few large bristle-like hairs. Anal plate broadly pyramidal in shape, so that it projects posteriorly as a knob, covered with numerous large stiff hairs. Genital plate oval to square, bearing several short stiff hairs, but the scales less bristly.

Larval life. Moults four times. Duration of larval life from eight to ten days. The moults occur at intervals of about two days.

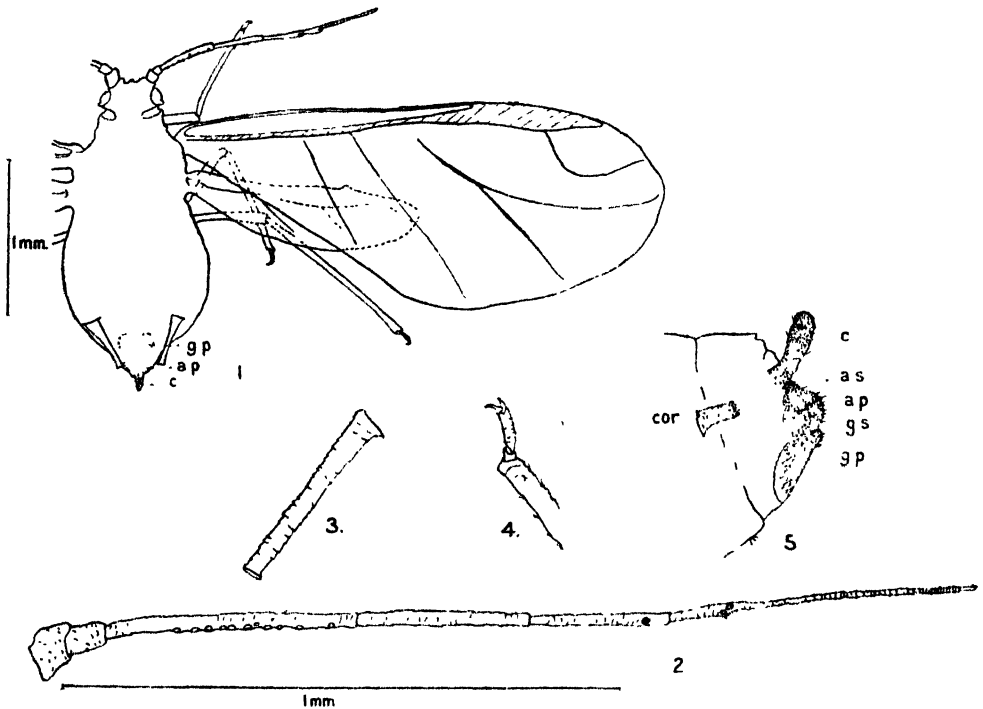


FIG. 3. *Myzus cerasi*, F., winged viviparous ♀. (1) dorsal view; (2) antenna; (3) cornicle; (4) tarsus of 3rd leg; (5) lateral view of caudal apparatus. *c*, cauda; *as*, anal slit; *ap*, anal plate; *gs*, vaginal slit; *gp*, genital plate; *cor.*, cornicle, cut short

MALE.—Approximate body measurements, 1.6 mm. by 0.7 mm. *Body*: general colour deep black; abdomen, dusky brown, with more or less black blotches on each segment dorsally, giving the appearance of broad stripes. Slight constriction between thorax and abdomen. Thoracic plates bulging considerably both ventrally and dorsally. *Head* deep black, bearing a few short hairs; frontal tubercles large and porrected and a sensorium in the mid-line between them; eyes red, compound. Antenna 6-segmented, dusky, each segment bearing several short hairs; segments 3, 4 and 5 are swollen and covered with a large number of similar circular sensoria; there is also a large sensorium at the tip of segment 5, and a group of them at the base of the unguis on segment 6; approximate measurements of antennae: total length, 1.8 mm.; segment 1, 0.08 mm.; 2, 0.08 mm.; 3, 0.45 mm.; 4, 0.28 mm.;

5, 0.23 mm.; 6, 0.65 mm. *Thorax*: wings transparent, with brown nervures and stigma; approximate length of wing, 2.4 mm. Legs dusky, except proximal portions of femora and tibiae; several hairs borne on legs, most numerous at distal end of the tibiae. *Abdomen* brown in colour, with black blotches dorsally, pear-shaped; cornicles black, 0.3 mm. in length; cauda conical, slightly constricted near tip, covered with short bristly scales and bearing a few long stiff hairs; anal plate also clothed with bristly scales and bearing numerous stiff hairs. Ventral to the anal plate is the genital apparatus, consisting of copulatory style (a stiff sheath enclosing the penis, which can be projected some distance from it) and two plates covered with stiff bristly hairs and scales, at the base of and ventral to the copulatory style.

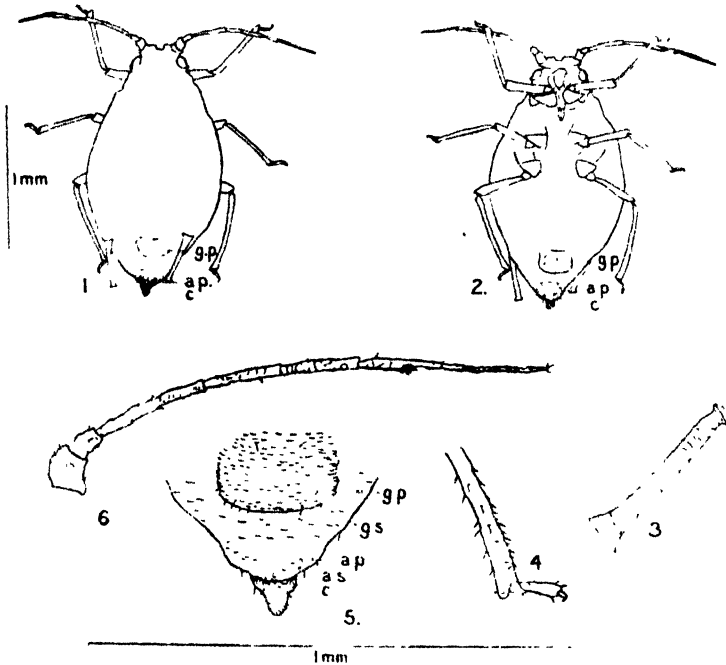


Fig. 4. *Myzus cerasti*, F., apterous viviparous female on *Galium*: (1) dorsal view; (2) ventral view; (3) cornicle; (4) tarsus of 3rd leg; (5) caudal apparatus, ventral view; (6) antenna: c, cauda, a.s., anal slit; a.p., anal plate, v.s., vaginal slit; g.p., genital plate.

OVIPAROUS FEMALE.—Approximate body measurements, 1.6 mm. by 1 mm. *Body*, greenish brown in colour, oval, pointed at both ends. Two or three large eggs are usually visible through the body wall of the adult female. *Head* slightly darker than rest of body; bearing several short hairs; frontal tubercles distinctly porrected; eyes compound, with an ocular tubercle, red. Antennae six-segmented; segments 3 and 4 pale, the others dusky; one sensorium present at tip of segment 5, and a group at the base of the unguis of segment 6; each segment bears several short hairs; segment 1 slightly gibbous. Approximate length of whole antenna, 1 mm.; segment 1, 0.08 mm.; 2, 0.05 mm.; 3, 0.23 mm.; 4, 0.18 mm.; 5, 0.18 mm.; 6, 0.32 mm. *Thorax*: first two pairs of legs pale in colour, bearing several hairs, especially upon the tibiae; third pair dusky; the tibiae swollen in the basal half and with numerous similar circular sensoria embedded in this swollen part. *Abdomen*: cornicles dark, 0.3 mm. in length, resembling the cornicles of the preceding forms. Caudal and genital apparatus much resembling that of the viviparous female on *Galium*, covered with bristly scales and stiff hairs; cauda conical; anal plate oval and knob-like; genital plate oval and with only a few bristly scales.

EGG.—The winter egg, when deposited, is oval in shape and of a shining olive-green. A few hours after deposition it changes to a bright shining black, and in this condition it withstands the winter frosts. Approximate measurements, 0.79 mm. by 0.42 mm.

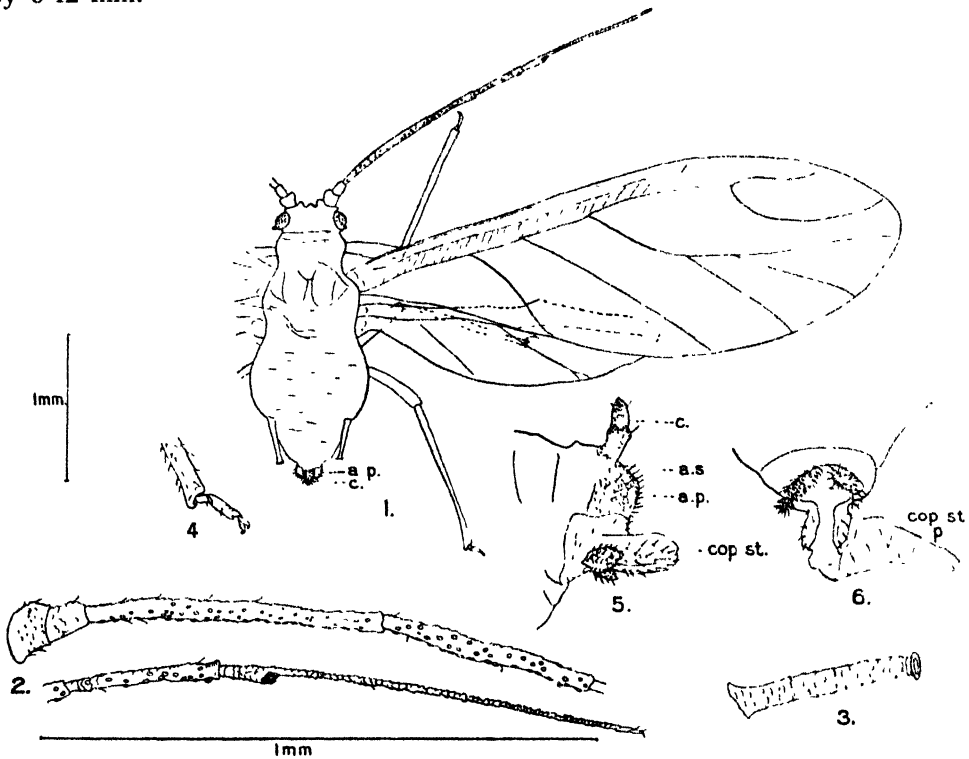


Fig. 5. *Myzus cerasi*, F., ♂: (1) dorsal view; (2) antenna; (3) cornicle; (4) tarsus; (5) caudal and genital apparatus, lateral view; (6) genital apparatus, ventral view; *cop. st.*, copulatory style; *p.*, penis; other letters as before.

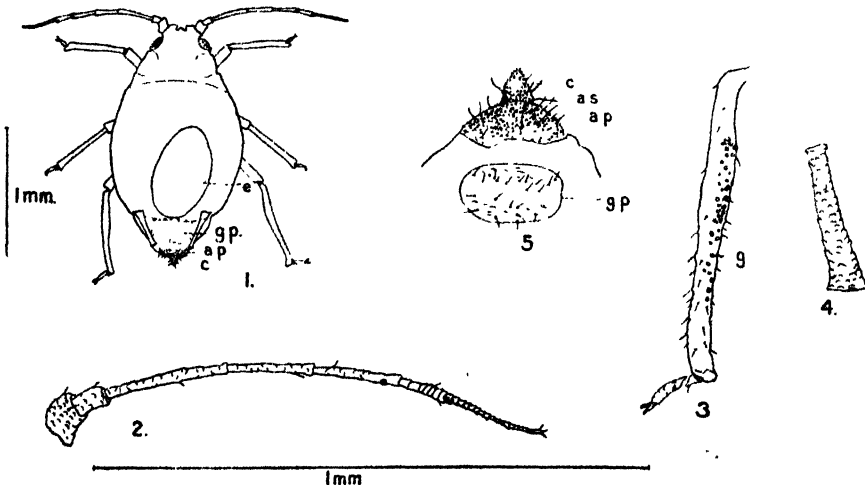


Fig. 6. *Myzus cerasi*, F., oviparous ♀: (1) dorsal view; (2) antenna; (3) tibia with sensoria, and tarsus of 3rd leg; (4) cornicle; (5) caudal apparatus, ventral view; *c.*, cauda; *a.s.*, anal slit; *a.p.*, anal plate; *g.p.*, genital plate; *e.*, egg.

Earlier Observations on the Life-history.

Most of the work on the life-history of this species seems to be reported from Canada and America. In 1908, C. P. Gillette⁷ described the forms found on cherry, and in 1917 he put *Myzus cerasi* in a list of Aphids which he considered to be good examples of economic American species that completely lack the alternating habit.⁸ In 1918, W. A. Ross,¹ of the Vineland Station, Ontario, described the life-history as it occurs in Canada. He gives the alternate food-plant as a species of *Lepidium*, the wild pepper-grass, and describes the forms produced upon it. Wilson & Vickery¹³ give the following host-plants of *Myzus cerasi*: *Ophrys aranifera*, *Photinea serratula*, *Prunus avium*, *P. cerasus*, *P. domestica*, *P. mahaleb*, *P. persica*, and *P. serotina*; but this is also only for the Western Hemisphere.

In Europe the only reference to an alternate food-plant that can be found is a paper in Russian by Dobrovliansky⁵, of which it has been possible only to read an abstract,⁶ but in which he reports that winged Aphids were found upon *Galium uliginosum*, L. (swamp bedstraw), in June. They greatly resembled winged forms of *Myzus cerasi*, and larvae in the first stage were also present, but the absence of both nymphs and wingless forms showed that the winged insects had migrated from some other plant. Experiments were made transferring winged forms of *Myzus cerasi* from cherry to *Galium uliginosum*, and these demonstrated that this species can migrate either to *Galium* or to *Veronica*, the summer generations on these plants being known as *Myzus aparines*, Kalt.

Dobrovliansky further states that *Myzus cerasi* also breeds during the whole summer on cherry without migrating, though "to a somewhat restricted degree." The writer's own observations confirm Ross's work,¹ with the exception of the alternate food-plant, which is obviously different in the two hemispheres; and agree with Dobrovliansky in that *Myzus cerasi* has been found to migrate, during June, to *Galium*. In Kent, however, it has been found only upon one species of *Galium*, namely, *aparine*, and never, so far, upon *Veronica*.¹⁴

Life-history as traced by the Author.

The writer tried to observe the Aphids in their natural surroundings, and only resorted to artificial protection (muslin bags over the plants and the provision of fresh food) when enemies seemed likely to obliterate all the broods under observation.

The date on which the eggs hatch varies with the weather conditions. In 1923, there were a few warm days at the end of February, and all the eggs had hatched by 1st March. A very cold March followed, and the fundatrices or stem-mothers did not reach maturity until 10th April. In 1924, February and March were cold, and the eggs did not hatch until 23rd March. Some eggs were delayed considerably by more cold spells and hatched as late as 6th April. The length of larval life again varies with the weather conditions, as the young fundatrices frequently have to withstand very cold winds and severe frosts after they are hatched, and these naturally delay development. They are of an olive-green colour at first and are to be found among the clusters of cherry buds at the tips of the branches. When the buds open, they collect upon the stalks of flowers and leaves and suck the juices from these fresh green tissues.

The fundatrices, when mature, produce young apterous viviparous females at the rate of 3 or 4 a day. Their length of life probably varies with the weather conditions. Gillette⁷ gives the productive period of the fundatrix as 30 days, but in 1923 a fundatrix, hatched on 1st March, was found alive by the writer at the beginning of July; she produced young from about 12th April till 6th June, but this was probably an unusually long-lived and productive fundatrix. During May the weather is generally favourable for reproduction, which proceeds rapidly, so that the 5th or 6th generation is reached before the winged forms appear in the broods

during the first fortnight in June. These winged viviparous females, the migrants, seem to appear in all generations.

All through June and July numbers of winged forms are produced on the cherry, and as these migrate as soon as they are mature, the broods tend to get smaller towards the end of July; there are then fewer winged forms about, and the few apterous ones left behind are almost all demolished by their many enemies—chiefly Coccinellids, Syrphid larvae and parasitic Hymenoptera. In 1923 there were no Aphids left on the cherry at all by the end of July; the Coccinellids had not appeared in large numbers till the beginning of July and by then there were no fresh young shoots to which the Aphids might escape. In 1924, the enemies seemed to get a firm hold by the end of June, and most of the broods were destroyed, except for a few from each that fled to the tips of the shoots. These remnants formed the basis of broods that were flourishing again in July, when the Coccinellids were much fewer for some reason. Most of these broods were dying off by August, though a few isolated broods continued feebly breeding till September and October.

Winged viviparous females of *Myzus cerasi* were found breeding upon *Galium aparine* during June and July. Their offspring are apterous viviparous females, and during July and August several generations are produced upon *Galium*. By the middle of September winged forms appear in these broods and soon they can be found singly upon the undersides of cherry leaves; these are the female alate sexuparae, which give rise upon the cherry to oviparous females. In 1923, as stated elsewhere,¹⁴ the writer failed to find these winged forms on the open *Galium* of the hedgerows, but they were produced on plants protected by muslin bags. In 1924, however, the alate female sexuparae were found in five or six different patches of *Galium*, open in the hedgerows.

A little later (1st October in 1923 on protected plants and 30th September in 1924 on open plants) winged males appeared in these broods, but they soon flew away from the *Galium* plants, which were by this time browned and dried up. During early October an occasional male can be found on the underside of cherry leaves in company with wingless oviparous females, and sometimes a belated female alate sexupara. Pairing takes place between the winged males and the oviparous females, and the eggs are laid, these being pale yellowish green for a few hours after deposition, but soon changing to a shining black. They are deposited amongst the scales just below the cherry buds, and are then ready to withstand the winter, until they hatch into the fundatrix in the spring.

Undoubtedly *Galium aparine* is one of the alternate host-plants of *Myzus cerasi*, at least in Kent. The spring migrants from the cherry were found on this *Galium* at Wye, at East Malling, and at Brenchley.

A brood that was sleeved on a cherry shoot on 12th August this year seems to show that an alternate host-plant is necessary for the production of males. Nearly a thousand winged forms were produced by this brood from 2nd September till 16th October, and though nearly every one was examined, no single male specimen was found. They were all female alate sexuparae, whose progeny were oviparous females, and by 3rd October the brood was swarming with the latter, all in a distended and restless condition. These facts agree with Ross's observations that the Aphids can continue breeding on the cherry during the whole summer, and that oviparous females may be produced without the use of the alternate host-plant. The males, however, cannot be produced on the cherry, so that the alternate food-plant is necessary to complete the life-cycle. This is an important point economically; for if the winter egg cannot be laid without the help of the males from the alternate host, a good deal can be done in the destruction of the pest by cutting hedges and clearing away patches of *Galium aparine* before October, when the males appear. Hedge cutting during the first week in September, or even earlier, will help in the destruction of winged female sexuparae as well.

Summary of the Life-history.

		<i>Cherry.</i>	<i>Galium aparine.</i>
January	...	Winter eggs.	
February	...	Winter eggs.	
March	...	Newly hatched wingless stem-mothers.	
April	...	Mature stem-mothers and their offspring, which are wingless females.	
May	...	Generations of wingless females.	
June	...	Wingless females and winged females, which latter fly away to <i>Galium aparine</i> .	Winged females from cherry produce wingless females on <i>Galium</i> .
July	...	Wingless females and winged females, which latter fly away to <i>Galium aparine</i> .	Winged females from cherry and generations of their offspring.
August	...	A few feeble colonies of wingless females may persist on cherry.	Generations of wingless females.
September	...	Any wingless females there are left on cherry produce winged females which remain on cherry.	Wingless females produce winged females, which fly to cherry and produce egg-laying females there.
October	...	Winged females from <i>Galium</i> or from other cherry trees give rise to egg-laying females. Winged males from <i>Galium</i> pair with these and eggs are laid.	Wingless females produce winged males, which fly to cherry and pair with oviparous females.
November	...	Winter eggs.	
December	...	Winter eggs.	

Natural Enemies.

The following insects have been observed by the writer to prey upon *Myzus cerasi* :—

On Cherry.	On <i>Galium aparine</i> .
Coccinellids and their larvae.	Very young spiders of the family EPEIRIDAE.
Syrphid larvae.	Immature Anthocorid bugs, species unknown.
BRACONIDAE.	BRACONIDAE.
<i>Ephedrus lacertosus</i> , Hal.	<i>Ephedrus lacertosus</i> , Hal.
<i>Aphidius</i> sp.	<i>Trioxys brevicornis</i> , Hal.
<i>Aphidius</i> sp.	<i>Aphidius cerasi</i> , Marsh.
<i>Aphidius</i> sp.	
PROCTOTRYPIDAE.	CYNIPIDAE.
<i>Lygocerus aphidivorus</i> , Kieff.	<i>Allotria flavicornis</i> , Htg.
	PROCTOTRYPIDAE.
	<i>Lygocerus aphidivorus</i> , Kieff.

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THE NATURAL CONTROL OF THE LEAF-MINER *PHYTOMYZA*
ACONITI HENDEL (DIPTERA) BY *TACHYDROMIA MINUTA*,
 MEIGEN (DIPTERA).

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During the summer of 1924 the writer was engaged in research upon the feeding habits and the structure of the mouth-parts of Diptera. Among the families of Diptera that were studied were the EMPIDAE, and one of the most interesting members of this family is *Tachydromia minuta*, Meigen, since it is among the few British Diptera, other than the Asilidae, that are entirely predacious.

T. minuta is essentially a plant-haunting species, feeding on the small flies and other insects which frequent the leaves of many plants, and amongst its prey was noticed the leaf-miner, *Phytomyza aconiti*, Hendel.

P. aconiti belongs to the family AGROMYZIDAE in the Acalyptrate Diptera, the larvae of most of the species of the family mining the leaves or stems of plants and a few living in the galls of other insects. *P. aconiti* is said to mine the leaves of *Aconitum* and *Delphinium*. It is a comparatively new species, Hendel having described it in 1918, and, according to Mr. J. E. Collin, this is the first record of its occurrence in Britain.



Fig. 1. *Tachydromia minuta*,
 Mg., ♀. × 20.



Fig. 2. *Phytomyza aconiti*,
 Hendel, ♀. × 15.

At the time that these records and observations were made the writer was unaware that *P. aconiti* was unknown in Britain, and only ascertained the fact upon presenting a specimen to the British Museum for identification. His attention was first attracted, about the beginning of August, by the great number of *P. aconiti* upon a certain clump of delphiniums situated in a garden at Streatley-on-Thames, where much of the research was being carried out. The flies were running about all over the surface of the leaves, which were mined to an appreciable extent by their larvae, and amongst them were noticed occasional *Tachydromia minuta*, which on examination were found to be actively predacious upon the leaf-miners.

As the *Tachydromia* was of great importance for the research that was being carried out at the time, very close observation was made upon its feeding habits,

and when it was noticed that its activities were causing a decrease in the number of *Phytomyza aconiti*, accurate records were made of the proportions of the two insects upon the delphiniums.

For a little over a week nothing of interest was noticed beyond the fact that the *Phytomyza* were noticeably spreading, since, when first observed on 2nd August, they were confined to two clumps of delphiniums, but by 6th August they had spread to the next clump, and by 11th August the next two clumps were heavily infested. After the first week, however, it was obvious that, while the *Phytomyza* continued to spread, the *Tachydromia* were also most certainly beginning to increase in numbers, and could be seen at almost any time of the day, running about the leaves and frequently attacking the miners. From 6th to 14th August the *Phytomyza* were still increasing, but there was also a very marked increase in the numbers of the *Tachydromia*, the proportions of the two insects on the latter date being about 5 : 2. These proportions were based on the average number of insects upon each leaf, which was arrived at by taking about twenty or thirty leaves at random from each plant, counting the numbers of the two species of flies upon them, and working out the average from the figures thus obtained. From 14th to 17th August the Empids increased rapidly, and as far as could be calculated with any accuracy, the proportions were then about 4 : 3.

From 17th August onwards the *Tachydromia* steadily increased in numbers, and the rate of increase of the *Phytomyza* began gradually to slow down; by this time the latter had spread from the two original clumps to every clump in the bed, which consisted of delphiniums alternating with hollyhocks and Michaelmas daisies. The bed was separated from a similar one only by a small grass path about two feet wide, but although very careful search was made, no leaf-miners were detected upon the second bed.

By 22nd August the *Tachydromia* had so greatly increased in numbers that the proportions were about 1 : 1, and the rate of increase of the *Phytomyza* was obviously declining; by 28th August the *Tachydromia* actually outnumbered the leaf-miners. From this point the *Phytomyza* began to decrease, at first quite slowly, but after a while very rapidly, until by 14th September they had so dwindled in numbers that on many of the clumps they were not to be found in the adult stage at all, and on the remaining clumps they had to be searched for. By 18th September they had entirely disappeared, and up to 22nd September none had reappeared on any of the plants.

The *Tachydromia*, on the other hand, had been steadily increasing every day, and by 18th September were swarming all over the delphiniums, but from then on they began to disperse, and a week after the disappearance of the *Phytomyza* they too had practically all disappeared, and only a few were to be seen hopping about the leaves of the various plants in the bed.

It will thus be seen that this was a definite case of selective predacity, and in order to realise the better how the *Tachydromia* controlled and eventually exterminated the *Phytomyza* the figures have been set out in the form of a graph (fig. 3).

It will be seen that at the time when the observations were commenced the *Phytomyza* were very numerous, and were spreading rapidly; they did not, however, increase in numbers upon the original plants, but spread to the adjacent clumps of delphiniums, which accounts for the straight line of the graph up to 14th August. The erratic curve is entirely due to *Tachydromia minuta*, and it will be noticed that there is a fall in the numbers of *Phytomyza* corresponding to the increase in the *Tachydromia*.

The curve of *P. aconiti* is perfectly normal, reacting as it does to that of *T. minuta*. The curve for the *Tachydromia* presents some exceedingly interesting features, however, and is in striking contrast to the many cases where the increase of a parasite

has been shown graphically. The Empid being a predator and not a parasite, it does not breed on the plants, and its numbers upon a particular plant are as much subject to fluctuation as those of Muscids upon a patch of dung. Exactly what factors influenced its sudden fluctuations the writer was not able to determine, but the general trend of its increase was obvious. About 6th August it started gradually to increase, but its numbers went up suddenly about 12th-14th August, and from then onwards the increase was steady and rapid until 4th September, when, for some unknown reason, it remained steady until 12th-14th September; then followed the extremely sharp rise until the apex was reached by 18th September. Coincident with the apex of the increase of *T. minuta* is the extermination of *P. aconiti*, and almost immediately afterwards the numbers of *T. minuta* fell rapidly, there being left, in a week's time, only the normal few running about the leaves of the various plants of the bed. Very careful search was made for any signs of a Chalcid or other parasite, but none was found; so that there can be very little doubt that the extermination of *P. aconiti* was due to *T. minuta*.

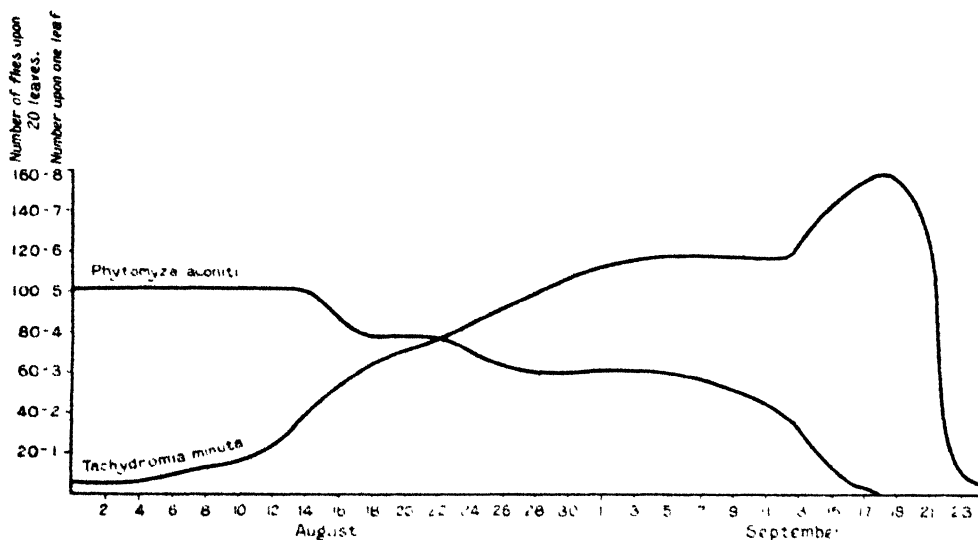


Fig. 3. Graphs showing the increase and decrease in the numbers of *Phytomyza aconiti* and *Tachydromia minuta*.

The important point is that any one species of insect should so attract a predator as to cause its own extermination. The surrounding district happened to be a favourable locality for *T. minuta*, which the writer has never seen so common anywhere before; the probability is then that, finding an easy prey in *P. aconiti*, it collected where food was plentiful. Naturally, when the supply of food ceased, the *Tachydromia* dispersed, the normal conditions of insect-life upon the particular plants quickly reasserting themselves.

It would seem, in view of this case, that some use might be made of the smaller predacious Diptera, by introducing them into greenhouses which are suffering from pests similar to *P. aconiti*. The smaller EMPIDAE in particular might be of use in controlling "white-fly" and similar insects.

The author's thanks are due to Mr. J. E. Collin, who very kindly determined the identity of *P. aconiti* and furnished much information concerning it, and to Major E. E. Austen, D.S.O., for determining *T. minuta*, and also to Mr. D. E. Kimmins for the photographs of both insects.

THE TSETSE-FLY PROBLEM IN THE NZEGA SUB-DISTRICT, TANGANYIKA TERRITORY.

By C. F. M. SWYNNERTON.

(PLATES II-IV.)

I.—Introduction.

The Nzega sub-district of the Tabora district lies between Tabora itself, on the Central Railway and the Shinyanga sub-district, also of Tabora, which lies further north and adjoins the Mwanza district. The map which accompanied my recent paper on Shinyanga (Bull. Ent. Res. xv, pp. 313–337) was intended to illustrate the present paper also, and should be referred to freely.

It will be remembered that Shinyanga presents a case in which the tsetse has completed its invasion of the bush areas and is now in process of driving the main population out of the open country.

Nzega is still at the earlier stage. It is true that the fly has in places reached the more open and better populated country and begun to drive the people back, but for the most part it is still engaged in advancing through the less inhabited bush. The position is thus very largely equivalent to that which exists in parts of Rhodesia and Nyasaland. Fortunately, large population is close at hand, and if we can get it really interested in its problem before the latter reaches the stage it has arrived at in Shinyanga, we ought to be able to obtain some instructive results. For this reason work has been begun on the Nzega problem conjointly with that in Shinyanga.

I have stated elsewhere my opinion that the tsetse problem will not be solved on a great scale without the co-operation of the natives and that the prospects of effective co-operation have been lessened where it has been the policy to weaken or ignore their tribal organization. I am very grateful to Mr. J. E. G. Ransome, the Administrative Officer in charge, for his keen support and assistance in the direction of obtaining this co-operation in Nzega, and for the thoroughly successful way in which he helped to hold up grass-burning in the area which chiefly mattered (Mwambiti-Mwansimba).

II.—The Country.

Here, and everywhere in my papers and reports, the term “*Brachystegia* wooding” is used to include the allied genus *Berlinia* and the trees usually associated with these two genera ecologically.

The Nzega sub-district is undulating and for the most part granitic. It occupies part of the easterly section of the great *Brachystegia* bush area that extends from south Bukoba, past Kazi-Kazi, Tabora and Kigoma on the railway line, into Ufipa. Thence, passing between Lakes Tanganyika and Nyasa, this bush area enters North Eastern Rhodesia. It constitutes the Territory's enormous western fly-area, infested in the main with *Glossina morsitans*.

In this bush, in the Nzega sub-district, are three good-sized “culture steppes” or cleared settlements—that of Mwambiti-Nyawa in the east, Ndala in the south, and Makarundi-Nzega (very large) in the north-west. As a broad border to the Wembere, the bush is replaced on the east by an open limestone-cotton-soil steppe, largely uninhabited owing to soil conditions that are alternately droughty and water-sodden, but with fine grazing. Some big open “mbugas” (seasonally swampy ground) occur along the Manonga also. It was these two areas that the Germans proposed to irrigate from Lake Victoria and, subject to any effect it might have on the lake host, the project might still prove worthy of consideration to-day.

Additionally, much of the present bush country of Nzega has in the past been culture steppe, opened and kept open by sheer native settlement. In reverting to bush some of it has gone back to *Brachystegia* (where this was still unexterminated), some to *mzima* (*Terminalia*) which, occurring normally in *Brachystegia* wooding, survives the extermination of the actual *Brachystegias* and *Berlinias*.

The distribution of the different types of bush to-day is shown very approximately in the map.

The population of the culture steppes, including, however, a smaller number of natives who live in the bush, is 130,000, and the number of their cattle 280,000. The people are for the most part Wanyamwezi, essentially the same tribe as the Wasukuma of Shinyanga and Mwanza and nicely combining cultivation with cattle keeping; but Wairamba are present amongst them in Mwambiti especially, and Wataturu are found, principally in Makarundi, where they are survivors from the invasions which I shall describe below. The Wataturu are mere cattle-keepers.

III.—History of the District.

I follow my usual custom in giving the native history of the area, as there is always something to be learned from it. The chief lesson for ourselves in this region consists in the fact that an unpopular chieftain may cause the depopulation of an area and a consequent up-growth of bush and influx of tsetse. I have known thinning of population to occur where the cause for unpopularity was far less extreme than in one of the instances I shall give, and I have known dispersal of man and influx of tsetse to occur also from the deposition of a chief, who, unsatisfactory as he may have been from our point of view, was at least popular with his people. It is of the utmost importance to successful tsetse control that variation in population should be watched for by Administrative Officers, and their causes remedied in time, and that no measures should be pushed so hard as themselves to become unpopular.

In the Nzega sub-district great portions of the bush areas between Ngulu and the Manonga, the German road (see Map) and west Nzega (Nzega proper) and throughout north Uyogu were formerly culture steppe. Tradition and traces of old habitation show that the same position existed still longer ago in the bush between Ibologelo and the Wembere steppe.

The history of the depopulation of these areas begins with invasions of their Bantu (Wanyamwezi) inhabitants by the Hamitic Wataturu from the East. These latter finally established a domination over the Wanyamwezi and constantly came round with numbers of pack-donkeys, exacting tribute in the form of grain. The facetious formula invariably used was "our chief's wife has had a son and she wants some food for it."

Mtinginya, predecessor of Siyota, who preceded the present Sultan of Mwambiti, Mwanasali, formed an alliance with the Masai, offering them a share in the cattle that would be captured, and with their aid defeated the Wataturu. In a second campaign he expelled them from the country, except a certain number amongst those who had formed relationships with the Wanyamwezi of Makarundi and were concealed by them.

The remaining Wanyamwezi chiefs, freed thus from the oppression of the Wataturu, refused to acknowledge Mtinginya's claim to overlordship as they had previously refused to help him, and fighting followed. In these wars and those with the Wataturu much country was depopulated, and has to-day grown up into bush that is in part already invaded, in part still being invaded, by tsetse-fly.

More recent depopulations resulting in up-growth of bush have taken place also.

Thus, Sultan Siyota, succeeding Mtinginya, oppressed his own people, by (it is said) shooting their cattle for sport under pretence that they were elands, by seizing girls that attracted him, and in many other ways. He was deposed by our administration and deported to Kilwa, but he had already caused the depopulation of a piece of culture steppe for a number of miles round his headquarters. This is now covered with areas of young *Brachystegia* bush that have grown up in consequence, and with which *G. morsitans* is at this moment establishing contact.

Another Sultan engaged the people near him in such extensive works that they regarded them as a hardship, and his immediate neighbourhood also became deserted and grew up into tsetse-infested bush.

Makarundi stands out in contrast to these instances as an area which, by the actions of its own people under a wise chief in the past, has made itself safe, in very large part, against any future encroachment by bush and by fly.

Kwanda, three sultans back from Humba, the present holder of the office, is said to have enacted that instead of making long journeys to the bush for firewood, his people should dig up the stumps. Whether this is correct, or the people did it of their own accord, the result is visible to-day in the shape of fine stretches of clear grass-land on what, Sultan Humba tells me, used to be chiefly *Brachystegia* bush.

IV.—The Situation as regards Fly.

The possible importance of the bush distribution shown in the map (Bull. Ent. Res., xvi, pt. 4) lies in the fact that I have never yet found *Glossina swynnertoni* in extensive *Brachystegia* wooding, nor *G. morsitans* a very great many miles away from it in the drier types of *Acacia* wooding that characterize most of Nzega, Shinyanga, Mwanza and Dodoma. It is possible, but by no means certain, that *G. swynnertoni* cannot permanently invade *Brachystegia* wooding, nor *G. morsitans* the dry types of *Acacia-Commiphora* wooding that are here referred to. If this should be the case we should have the position in the Nzega sub-district that *G. morsitans* has on some of its fronts nearly reached the possible limits of its permanent advance. This, as I have said, is not certain, and it would be wrong to count on it. *G. morsitans* is, in any case, a lover of the borders of seasonal swamps (mbugas) lined with ilula acacias, and its invasion therefore of the Manonga River east of Mount Kisuge might have the results I shall refer to below.

There is greater certainty that all the following areas are suitable for invasion by *G. swynnertoni*: (a) the strip of bush that fills the country between the Manonga and the culture steppes to its south, (b) on the east, the wooded country between the Ibologelo culture steppe and the limestone steppe of the Wembere, (c) the central strip that divides the Ibologelo steppe from Nzega proper and that still contains patchy *Brachystegia*, but more largely *Acacia*, (d) the southern margin (in Uyogu) of the Makarundi-Nzega culture steppe, and (e) the "Nzega proper" portion, half bush, of the last-named steppe. These comprise practically all the country that is still uninvaded.

Advances by tsetse would appear to be taking place on the following six or seven fronts, which are as yet, in every case but one, in bush country. In each case cattle have of late been driven out. I list them in their order of urgency:—

(1) An invasion by *G. swynnertoni*. This fly has crossed the Manonga in about the last four years in the neighbourhood of Mount Kisuge and is spreading thence south, east, and possibly west. It has joined up with *morsitans* front no. iii, apparently since October 1923, when I first investigated, and it is now bearing down towards Gulube, Mwanasali's headquarters on the Manonga, and driving in the cattle-keepers on the way.

(2) Apparent advances by *Glossina morsitans* are as follows :—

(i) From Lusu and Mwansimba (see Map) westward. This advance threatens the Sultanates of Maungoi and Nzega proper. The fly has already, in the last two years, reached the edge of this culture steppe in the north-east of the Nzega Sultanate, and has driven the cattle from the nearest villages. Their owners are following them, and there is reason to fear that the fly may yet make Nzega untenable for some miles further. Flies followed myself nearly to the rest camp at Kiguhumo and right into the villages referred to above, and would doubtless have followed further had I not driven them off. There can be little doubt that the fly is already frequently carried across the Tabora road at this point (between the Administrative station and Kiguhumo) on the backs of the natives. The threat to the road adds to the urgency of the case, as does the relative proximity of the "Boma" or Administrative station.

(ii) From Mounts Ukusule and Buhondo eastward through the broad strip of wooding, previously uninfested, that follows the Manonga and still forms an essential reserve grazing for the Sultanates bordering on it; most of this latter still contains cattle, but occasional flies are found. The Makarundi portion of the small culture steppe that lies north-east of Mt. Buhondo and the settlement of Isaka, in the Kahama sub-district, have become involved in this advance. In the Makarundi section especially cattle and people are being driven out and the country is reverting to bush. A few miles of the present Shinyanga-Kahama is likely to become involved, but so much of this, just beyond, is already under fly, that this result of the advance is of less importance than the expulsion of the people.

(iii) From Lusu and Mwansimba eastward and southward. This advance has already passed Ngulu, Kazima and Kadoto to the east and immediately threatens the areas of young *Brachystegia* bush that Siyota's misdeeds have created in the culture steppe of Ibologelo.

(iv) An advance northward from and in Uyogu that extends across to near the Nzega-Tabora road. The very interesting position exists here that this advance, travelling north, has met advance no. iii travelling south, within the last two seasons.

(v) In addition, an advance is taking place—according to unverified native information—northwards in the bush country east of Ibologelo, the southern part of which bush country definitely contains *G. morsitans*.

V.—Discussion of the Situation.

The position created by the entry into the sub-district of *G. swynnertoni* would seem to be exceedingly serious, in that all evidence hitherto obtained shows that this fly is more tolerant than *G. morsitans* of dry conditions and more capable of invading the smallest woody growth and driving out the people.

On the other hand, *G. morsitans* seems much more capable than *G. swynnertoni* of invading country of seasonal swamps characterized by ilula acacias, and the arrival of the former fly on the Manonga might mean the more serious invasion of those areas of the Shinyanga sub-district (north of the Manonga and on the Mhumbo) that are so lightly infested with *G. swynnertoni* that cattle are kept in contact with it in the margins.

Of equal present urgency to the district are advances (i) and (ii) by *G. morsitans*. In each of these cases that fly has in the last two to three years reproduced locally the position for which *G. swynnertoni* has so long been responsible in Shinyanga, and in each case also a hitherto fly-free section of a main road is threatened. These two situations should be taken in hand at once. Advance no. ii can easily be dealt with

on the lines we are adopting in Shinyanga (Bull. Ent. Res., xv, pt. 4, p. 322). The commencement we have made in relation to advance no. i is described on p. 106.

Of greatest general interest are the advance by *G. swynnertoni* and advances (iii) and (v) by *G. morsitans*. These three invasions threaten from different directions a single piece of bush country, Mwambiti, lying west and south of Guluba (see Map), which is highly important as a late dry-season grazing area for the natives of Shinyanga and East Nzega. Can it be saved? Our work here during the next three or four years may supply a useful answer. Meantime, it may be of interest to discuss a discarded alternative, namely, measures against game, before I go on to describe what we are actually trying or proposing to try.

Presumably the game in the bush and man on the paths are, by their wanderings, promoting the present advance of the fly. There is no question of being able to exterminate the game in the area in the early future, for, in the first place, great reservoirs of game, from which it will continually be replenished, exist to the east in the Wembere and south Mwanza country; and secondly, even dense population has been unable to exterminate the dikdiks in the open culture steppes; how much less will hunting accomplish in a broad, uninhabited country of bush, long grass and thickets?

Can the animals be kept driven back? Unpaid European hunters are out of the question, for there would be no profit to them in shooting here. Encouragement to the large contiguous native population to hunt would have three effects: Hunters entering the area from Ibologelo round to Ngulu would tend to drive the game that inhabits or utilises the fly-free area into the infested areas, where its blood would become infected and whence, after the manner of game, it would always come back to its old haunts and habits on any relaxation of the persecution. Those hunters, on the other hand, who hailed from Tindi, Samuyi, Kizumbi, Makarundi, Maungoi and Nzega proper, would have to pass through tsetse-infested country to get to the hunting ground. Without great expenditure on supervision they could not be prevented from taking part in the hunting, and their hunting would take place largely or chiefly in the forbidden areas, contiguous to their own homes. The game would tend to be driven thence into the fly-free areas and the natives themselves would pass freely between infested and uninfested areas. The two factors together would produce a greatly augmented passage of game and man to and fro between infested and fly-free country and, incidentally, a greatly accelerated advance of the fly on every front.

The third effect may be illustrated from what has taken place in East Mwanza, where, owing to distance till lately from any sort of control, the population has been neglecting agriculture for hunting. The advent of sleeping sickness has enabled the situation to be dealt with, and I quote a passage from a letter lately received from Mr. A. M. D. Turnbull, the able Senior Commissioner of the district, describing the effect of the stoppage of the hunting.

"Early in 1922," he writes, "and in the preceding years, this population, reinforced by many hunters from outside, engaged habitually in game destruction. They owned practically no livestock. They looked to the game to supply them with 'kitowero.' They were not contributing to economic development. Now I find that most of them, settled as they are [by the Government] in fly-free areas, are leading more useful lives. They are cultivating cotton, ground-nuts and simsim, etc., and with the profits can acquire livestock."

Mr. Turnbull goes on to describe how elsewhere in his district also he is trying to stop hunting in order to turn his people, "if it can be done, into useful cultivators."

The converse of this process will be the effect of special encouragement to hunting in the Nzega district or anywhere else. Either hunting must come first, if it is to be effective, or development. We cannot have both. We must choose.

The remaining alternative would be to employ reliable salaried European hunters with salaried native assistants, the whole thoroughly well organised and composed. Only thus could we have any hope of halting the fly, and that hope, in thicketed country of this kind, would be of the very faintest; and owing to the great and uninhabited reservoirs beyond, the work would have to continue quite indefinitely.

Mr. R. W. Jack's large-scale measure on these lines in Southern Rhodesia (now discontinued) has shown two things—the great expense of the undertaking in the aggregate, and how very doubtful it is of result; for in his fourth year the game came in in greater numbers than ever, as the result, he considers, of an exceptional season. The fly had disappeared, apparently, from the spear-point of its advance—a strip that was particularly favourable to the operations, the forest being “open and accessible.” It is, perhaps, not sufficiently shown that the result was not due to the exceptional drought, or (next year) the exceptional rains, but quite likely it was the shooting. Probably, in these favourable circumstances, mere harrying of the game, or the isolation of the fly's dry-season centres, would be sufficient without extermination. As I suggested in 1921, “It is possible that the actual effect of the rinderpest may have been not directly to starve the fly, but to confine it the year through to a far greater extent to its dry-season centres by the destruction of its chief carriers.” Certain it is that the rinderpest produced its apparent effect on the fly without anything approaching wholesale extermination of the game; also that in great areas it had no visible effect on the fly at all.

Jack concludes that “in particularly favourable localities or where the land is of greater intrinsic value the elimination of tsetse-fly by organised game hunting on the part of paid hunters might not prove uneconomic,” but that “over large areas of indifferent country the application of the knowledge gained would need to take some other form than operations of the nature adopted for the purposes of the experiment . . . The results of the experiment cannot, therefore, be said to encourage any undertaking in the way of wholesale elimination of game” (Rh. Agr. Jnl., June 1923, p. 346). These results and conclusions support in detail my own view of the question as published in 1921.

Further, that the fencing of a small patch of country and the extermination of all large or largish animals in it would lead to a disappearance of the tsetse contained, if man is also excluded and, in the case of the reptile-eating tsetses, reptiles as well, is to my mind a foregone conclusion. It is when we come down to working out the application of this to actual conditions, as I have done in the case of Nzega, that we discover how much more complicated things are in nature and how misleading a merely academic experiment may be. I know myself at present only of one small fly-belt in which game extermination might conceivably be effective, and in this belt it is exceedingly likely that the situation could be dealt with otherwise, and without other than partial and localised measures against the game. That highly localised measures against game such as can be adequately guided and supervised may be a useful part of our general measures is another matter, as was shown at Kizubi.

VI.—Regulated Burning of Grass.

I would refer the reader to my paper on “The Tsetse Problem in North Mossurise” (Bull. Ent. Res. xi, pp. 324–325, 382–385). There I gave my views and reasons and discussed difficulties, administrative and other, with some fulness.

In view of misunderstandings I would repeat or add here a few points:—

(1) The country is in any case burnt off annually and most of the humus destroyed, and the game driven hither and thither, and most of the country has been so burned for hundreds of years without any useful effect. Why, then, should it not be burned

for a limited number of years in a fashion useful for the extirpation of tsetse-fly, and in a manner so planned that the driving of the game will so far as possible be harmless or useful?

(2) Where you cease burning country before you are ready to stock it fairly fully, it goes to bush and thickets that are capable of harbouring tsetse-fly and that so thicken that they become difficult and expensive ever to clear again. In each country cultivation by oxen is, in any case, impossible owing to the continued presence of fly.

(3) Where such objectionable thicket country has already become continuous and extensive, probably the best thing to do with it is to attempt to turn it over to valuable high forest, if that is cheaply possible, and to continue to preserve it from burning.

(4) We cannot usefully turn the entire country over to high forest, or, alternatively, permit it to go to tsetse-haunted thicket. We need pasture also and land that is not too difficult to clear for agriculture, and on which we can use ploughs and wagons drawn by oxen. The only way we seem likely to secure these desiderata at present out of land haunted by tsetse-fly is by clearing it or regularly burning it late in the dry season. Clearing will stop the formation of leaf-humus and burning will burn it, as now; but if we also banish the tsetse-flies, the cattle we introduce will supply an admirable substitute for it. Or, the tsetse once having gone and a barrier having been contrived against their return, it is always still open to us to allow such thickets to spring up again from the live roots still in the ground if we really prefer dense, low thicket and a scanty leaf-humus to grazing, manure and the use of animals.

(5) Forest reserves and established grazing would be protected against our fires just as they have to be against the present annual native fires.

(6) The administrative difficulty is a very real one. An officer who has not a good deal of time and interest to devote to the matter, or who is soft-hearted in the enforcement of the law and on whom babes and old women are readily palmed off each time as the culprits, can never secure the postponement of burning. Someone in each area should be in special charge during the critical months and be aided by energetic and trustworthy native guards and the co-operation of the headmen. He must thoroughly organise his protection of the grass and also think out well and supervise the organisation of the lighting. Not merely setting fire, but indulging in the bush in occupations likely to cause fires, must be forbidden. With us it was found that the majority of fires were caused by people burning earthenware in the bush. It was insisted that in the driest months they should burn it in their villages.

The best present hope of preventing the further advance of *G. swynnertoni* into the Mwambiti area appears to lie in a strictly enforced postponement of grass fires and well-organised late burning during each of the next few years.

The first instalment of this measure was carried out in Nzega in 1924. The fire included also the Lusu-Mwansimba *morsitans* area (advances nos. ii and iii). By utilising as a barrier some previous broad burning on the west and by a judicious choice of wind and organisation of the lighting, it was burned in such a way that it did not drive the fly into areas as yet uninfested—a misfortune which, I believe, is being brought about here by unregulated burning. The probable resultant movements of the game were also taken into consideration.

The fire, lighted at the end of the first week in September, was put in along the whole east and south with a south-east wind from Ibologelo to the Manonga River at a point west of Gulube, and from Ibologelo round to Stoke's Camp, and thence to a point north-east of Nzega Station, by a few hundred natives. Those burning between Ibologelo and the Manonga camped along the line the night before with

their food and water. For the protection of cattle-grazing a fire break had been hoed, narrow on the windward side, broad or re-inforced by burning elsewhere. It proved effective.

The results of this fire have been described in some detail in my paper on Shinyanga (Bull. Ent. Res. xv, pp. 313-337). In Nzega, as in Shinyanga, there are areas in which thickets, some of them extensive, are numerous, and these may require to be specially dealt with in order to make the fires fully successful.

The photographs showing the effects of burning at different dates which illustrate the present paper (Plates ii-iv) and my paper on Shinyanga (*l.c.* Plate xv) were taken (with one exception) in connection with my experiment in 1921 near Kilosa, but those of the October burning exactly represent what took place in 1924 in the Shinyanga-Nzega fire, my pictures of which were a failure.

I stated in my Shinyanga paper that, over an area of more than a square mile I littered with dry grass all thickets likely to exclude fires. The effect of the fire on these thickets is illustrated typically in Plate xv of that paper. I also stated that an immense number of small grassless thickets were burned right through, though they were not littered with grass. In the present paper Plate ii, fig. 1, represents an untreated thicket after the Kilosa fire and shows well the effect that was obtained on a far larger scale in Shinyanga and Nzega also. A glance at these and the remaining photographs will bear me out when I state that I have come across a great deal of evidence in Africa to support the conclusion that "savannah" or pasture wooding, as opposed to dense wooding or scrub which excludes pasture, is in most cases the produce of the annual fires, and that where these fires are severe the wooding is thinner and with less underbrush. A strong contrast in this respect may sometimes be seen on the opposite sides of a road which has for a few years been used as a fire-break.

The illustrations on Plate iii are also worth drawing attention to. It is said that by grass burning we encourage erosion. I have never seen, as the result of burning, the amount of baring of the soil and erosion which takes place as the result of overstocking; and the only remedy for this disastrous state of affairs lies in clearing or burning late for a few years. If either is successful the humus will follow later.

A barrier on the east side of the Lusu-Mwansimba *morsitans* area (advance no. iii) is impracticable owing to the great width of unbroken bush country here involved and the width that the barrier would have to be. The lack of water in most of it would not have been insuperable alone, for the provision of water by boring in places to which it is essential that settlement should be attracted is part of the policy recommended; but it might be difficult at present to spare adequate population and labour from the Ibologelo culture steppe to consolidate such a barrier.

Sultan Mwanasali of Nzega and Mwambiti (36,000 subjects) and Sultan Kasiga of Maungoi (7,000) came to my camp at Kizumbi when the clearing operations by the Shinyanga natives were in hand, spoke of the advances by fly in their area and asked me to come and show them where to clear. I went there early in July and found they had not waited for me, but that each had made a very considerable clearing in a place chosen by himself. These clearings are shown in the map. Mwanasali's, which is well done, at Stoke's Camp, and one begun by Ndambire, Sultan of Nyawa, each constitutes a contribution to the future splitting up of the infested bush areas, and to that extent they are distinctly useful; but they do not help us on with the emergency measures required at once. Mwanasali's clearing is well chosen in relation to possible consolidation by planting it with cotton.

Kasiga's clearing is intended as a safeguard against advance no. (i), which has come very near him, and is excellent also as a beginning in the protection of the road. Placed a little further east, to take advantage of the great Lusu mbuga and other spaces already open, the same amount of clearing would have covered much

more country, and Kasiga has now, on my advice, connected up most of these open spaces. What his people should clear in future is the entire piece of bush between their two present clearings. That will interpose an open space of some width between Kiguhumo (and the road) and the fly-bush. The Nzega country, half bushy, just north of Maungoi is even more seriously threatened, and Mwanasali's people should clear that front without delay.

Quite apart from advance no. (i), this protection of the culture steppe from Lusu mbuga to a point near Nzega will probably be very necessary, ultimately, in relation to the advance of *G. swynnertoni* from Kisuge, if we fail to push it back across the Manonga by means of late grass-burning; and as the clearing will have to be wide, it will be well to push on with it annually.

The augmentation of the barrier already commenced by Mwanasali at "Stoke's Camp" will be useful, ultimately, in relation to any marked extension of the present southward advance by *G. swynnertoni*.

The threat to "Siyota's" wooding should soon be dealt with—say next year—by clearing it. An immediate attempt to deal with the connection now being established between the Mwansimba and Uyogu-Nyawa fly-areas, by a narrow clearing following the Idudumo, might nip this also in the bud. The general situation in Uyogu (*morsitans* advance no. iv) can hardly be dealt with usefully yet by clearing, unless by denuding the places in which the fly concentrates each dry season; but it is proposed to try late burning here also.

Some of the clearings recommended are mere emergency measures. The correct method, I believe, in a *morsitans* area of the type we get here, is: First burn, as late and as fiercely as can be arranged, then clear or otherwise provide for the places in which the fly is afterwards found concentrated; thirdly, next year, burn again as fiercely as possible.

Probably the most useful experiment that can be attempted in Nzega district, and in relation to which Makarundi and Kahama could assist very greatly, is the treatment of the fly's dry-season concentration-centres in a selected area of mtundu bush infested by *G. morsitans*. The clearing of the Idudumo, already recommended, probably comes under this head, and a more comprehensive experiment will be attempted, if possible, later, when the demand for labour for the new railway, which is likely this year to necessitate the reduction of tsetse work in Shinyanga and Nzega to small dimensions, shall have come to an end.

An important point that was as obvious in Nzega as in Shinyanga was the immense advantage of being able to utilise the natives' own tribal organisation. It will probably be a great many years before we can educate the natives of the coast, where this system has lapsed, to give us the co-operation which we are receiving at the outset in Shinyanga and Nzega. Without this co-operation, and where the headmen have little influence, attempts at controlling tsetse will necessarily be handicapped.

VII.—Summary.

1. The Nzega sub-district of Tabora contains old savannah wooding (mostly *Brachystegia*), younger savannah wooding (in part *Brachystegia*, in large part *Acacia*) and grassy "culture steppe," or open settlement. There is also a large, natural, open grassy steppe, uninhabited, on the Wembere.

2. The younger wooding has grown up as the result of depopulation caused by clan and tribal warfare that pre-dated the entry of the Germans, though a little has been produced since by oppressive or unpopular chiefs.

3. The older bush is for the most part infested with *G. morsitans*, and the younger is in part infested, in part in course of becoming infested, by tsetse that appear to be advancing on several fronts. The largest bush area in the district as yet uninfested is that of Mwambiti, south and west of Gulube.

4. Much of the settled culture steppe being itself still very bushy, the advance of the fly to its borders would appear to constitute a serious threat, and the cattle and their owners are already beginning to be driven by *G. morsitans* out of culture steppe in north Makarundi and Nzega Ndogo, at a point south-east of Kiguhumo.

5. *G. swynnertoni* has recently passed into the sub-district from Shinyanga, is spreading, and, being particularly adapted to dry thorn-bush conditions, is probably capable of infesting all portions that are as yet uninfested, as well as all of the culture steppe excepting parts of Makarundi. *G. swynnertoni* is already in contact with the great thorn-bush area, Arusha to Dodoma, to the east of the Nzega sub-district, for it occupies areas in Mbulu and Mkalama.

6. The advances by *G. swynnertoni* and *G. morsitans* into the Mwambiti bush area are of somewhat special interest, for they are representative of what is happening in much of South East Africa.

7. The possibility of dealing with this situation by means of measures against the game has been carefully considered. The only effect such measures could have here would be to accelerate the advance of the fly owing to the movements of man and game that they would bring about and to divert the population from development of their country to hunting. Both these situations are already existing in East Mwanza and are proving difficult to remedy.

8. Means of producing and consolidating cleared barriers are under experimentation, but it would seem that at present the above-mentioned advance can be met, if at all, only by judiciously planned and organised late grass-burning.

9. Grass-fires in any case have for hundreds of years burned off the country. Their discontinuance, unreplaced by settlement and immediate heavy stocking with animals, leads to a vicious thicket growth that gradually suppresses all pasture, continues to harbour tsetse and is clearable only at the greatest expense. As, then, burning does and must take place, surely it is far better that in tsetse areas (not in cattle-areas) the fires should be organised in such a way that they will damage the fly and in a limited number of years replace the patchy, scanty humus of the thickets with well-distributed manure resulting from the grazing of cattle, than that the present indiscriminate and harmful system of burning should be allowed to continue.

10. The administrative difficulty is a very real one. A man who is over-busy in other directions, or easily imposed on, can never enforce the postponement of burning. Someone should, if possible, be in special charge during the critical months and be aided by legislation, energetic native guards and the co-operation of the headmen.

11. Postponement of burning was effected last year on these lines in nearly the whole Mwambiti-Mwansimba area with success. This area comprises both the advance by *G. swynnertoni* and two of the three most threatening advances by *G. morsitans*. The fire, as regards its carrying out, was most successful also. It will take three or more such burnings before the probable effect on the tsetse can be clearly seen, and work on the more extensive thickets may also first be needed.

12. On the west of the area bush-clearing is necessary to hold the fly back. The natives have already carried out a first instalment of this clearing near Kiguhumo and, near "Stoke's Camp" and Ndambire's, made a small beginning with the splitting up of the fly-belt on the lines indicated on the map. Their efforts

in the immediate future will be directed to the protection of the three culture steppes (Ibologelo, Nzega and North Makarundi) that are immediately threatened by *G. morsitans*.

13. In Nzega, as in Shinyanga, the value of using the tribal organisation was well proved. The natives still follow their chiefs and headmen as their natural leaders, and there can be no doubt that where this system has been allowed to weaken and headmen have lost their prestige, measures against the tsetse are going to be far more difficult to carry out.

14. South Makarundi offers a fine example of what can be done in the way of making culture steppe (and freedom from fly) permanent by getting the natives to dig up stumps for firewood instead of making journeys to the bush.



Fig. 1 The effect of a fire lighted on 22nd October on a dense tsetse-breeding thicket. Great numbers of such thickets were swept through by the Shinyanga-Nzega fire.



Fig. 2. Scrub killed to the ground by a late fire: photographed some months later. After earlier fires even the twigs shoot out again.



Fig. 1 Photograph taken in April of thorn bush that had been burnt through in the previous July. The scrub has not been affected



Fig. 2. Photograph also taken in April of similar thorn-bush that had been burnt through in the previous October. Much of the scrub has been killed. (Note the "stag-horning.")



Fig. 1. Effects of an early fire (July). Much of the grass is half-burned, and not burned at all round the bases of trees, in such places thickets spring up or extend and afford shelter and breeding places for tsetse

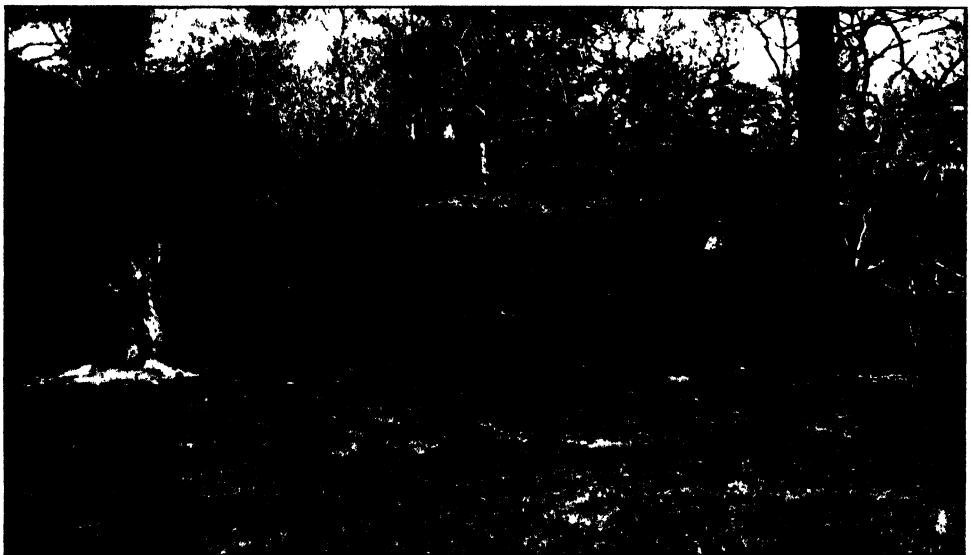


Fig. 2. Effects of a fierce fire on 22nd October with a hot sun and a good wind. The grass is burnt off clean and all small growth killed to the ground; many more logs are consumed than in fires lit earlier in the year.

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology, between 1st January and 31st March, 1925, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. T. J. ANDERSON, Government Entomologist :—1 species of Coccidae and 70 Psocidae ; from Kenya Colony.

Mr. E. BALLARD :—4 Lepidoptera and 6 larvae ; from Queensland.

Prof. H. A. BALLOU :—1 Beetle ; from Trinidad.

Capt. P. J. BARRAUD, Medical Entomologist :—6 *Lyperosia*, 6 *Stomoxys*, 3 *Haematopota*, 42 other Diptera, 43 Coleoptera, and 9 Rhynchota ; from Assam, India.

Dr. C. F. C. BEESON, Forest Entomologist :—4 species of Aphidae and 34 Orthoptera ; from Dehra Dun, India.

Mr. G. E. BODKIN, Government Entomologist :—50 Coleoptera and 3 Hymenoptera ; from Palestine.

Mr. N. N. BOGDANOV-KATKOV :—83 Orthoptera ; from Russia.

Dr. G. BONDAR :—37 Curculionidae, 7 Lepidoptera, 31 Isoptera, 6 Rhynchota, and 7 Orthoptera ; from Brazil.

Mr. J. R. BOVELL, Superintendent of Agriculture :—3 Lepidoptera and 2 Rhynchota ; from Barbados.

Mr. H. E. BOX :—36 Culicidae, 10 Tabanidae, 59 other Diptera, 43 Coleoptera, 162 Parasitic Hymenoptera, 16 other Hymenoptera, 43 Lepidoptera, 50 Isoptera, 4 species of Coccidae, 4 other Rhynchota, 50 Psocidae, 75 Mallophaga, and 3 Ticks ; from British Guiana.

Dr. P. A. BUXTON :—113 Siphonaptera, 6 Nycteribiidae, 19 Culicidae, 2 Hippoboscidae, 383 other Diptera, 8 larvae, and 2 pupa cases, 367 Coleoptera and 2 larvae, 392 Hymenoptera, 225 Lepidoptera and 7 larvae, 9 species of Coccidae, 4 species of Aphidae, 189 other Rhynchota, 82 Orthoptera, 6 Planipennia, 21 Odonata, 5 Mallophaga, 213 Spiders, and 62 Millipedes ; from Samoa.

Prof. T. D. A. COCKERELL :—1 Beetle, 13 Hymenoptera, 1 Moth, and 1 Coreid bug ; from U.S. America.

Messrs. G. H. CORBETT and B. A. R. GATER :—204 Diptera, 169 Coleoptera, 600 Parasitic Hymenoptera, 21 other Hymenoptera, 189 Lepidoptera, 3 Isoptera, 6 species of Aphidae, 3 species of Aleurodidae, 36 other Rhynchota, 8 Psocidae, and 11 Orthoptera ; from the Malay Peninsula.

Mr. H. H. CURSON :—50 Coleoptera, 4 Hymenoptera, 99 Lepidoptera, 4 Rhynchota, 12 Orthoptera, 7 Planipennia, and 2 Odonata ; from South Africa.

DIRECTOR OF AGRICULTURE, GAMBIA :—20 Coleoptera, 4 Lepidoptera, and 104 Rhynchota ; from the Gambia.

DIVISION OF ENTOMOLOGY, PRETORIA :—33 Coleoptera and 2 Parasitic Hymenoptera ; from South Africa.

Mr. P. R. DUPONT :—1 species of Coccidae from Seychelles.

ENTOMOLOGICAL STATION, PARIS :—10 Orthoptera ; from Africa.

Dr. E. W. FERGUSON :—3 slide preparations and 1 tube of Mites ; from New South Wales.

Mr. C. C. GOWDEY, Government Entomologist :—6 Coleoptera, 30 Formicidae, and 2 Lepidoptera ; from Jamaica.

Dr. J. W. B. HANINGTON :—51 Orthoptera ; from Northern Nigeria.

Mr. E. HARGREAVES, Government Entomologist :—9 Culicidae, 2 Tabanidae, 10 *Glossina*, 110 other Diptera, 470 Coleoptera, 3 Chalcididae, 41 other Hymenoptera, 18 Lepidoptera, 214 Thysanoptera, 17 species of Coccidae, 415 other Rhynchota, 55 Orthoptera, 2 Ephemeridae, 5 Hemerobiidae, 7 Trichoptera, 5 Plecoptera, and 100 Mallophaga ; from Sierra Leone.

Mr. H. HARGREAVES, Government Entomologist :—118 Diptera, 152 Coleoptera, 3 Hymenoptera, 36 Lepidoptera, 3 Rhynchota, and 7 *Bittacus* ; from Uganda.

Mr. F. HEIKERTINGER :—528 Coleoptera ; from Europe.

Mr. M. AFZAL HUSAIN, Government Entomologist :—100 Diptera and 15 Chalcididae ; from Punjab, India.

Dr. J. F. ILLINGWORTH :—9 Diptera ; from Hawaii.

Dr. A. INGRAM :—6 Siphonaptera ; from South Africa.

Mr. E. W. LANNIN :—24 Lepidoptera ; from Southern Rhodesia.

Dr. LI. LLOYD :—8 Diptera, 7 Coleoptera, 71 Hymenoptera, 73 Orthoptera, and 72 Odonata ; from Northern Nigeria.

Mr. G. A. MAVROMOUSTAKIS :—2 Coleoptera and 112 Orthoptera ; from Cyprus.

Mr. N. C. E. MILLER :—336 Coleoptera, 4 Hymenoptera, 786 Lepidoptera, 5 Rhynchota, and 1,501 Orthoptera ; from Tanganyika Territory.

MUSEUM NATIONAL D'HISTOIRE NATURELLE, PARIS :—125 Orthoptera : from various localities.

Prof. E. N. PAVLOVSKY :—4 species of Coccidae and 3 species of Aphidae ; from Turkestan.

Mr. A. W. J. POMEROY, Government Entomologist :—79 Diptera, 75 Parasitic Hymenoptera, 11 Lepidoptera, and 9 Rhynchota ; from Southern Nigeria.

Mr. M. RIABOV :—381 Orthoptera ; from the Caucasus.

Mr. A. H. RITCHIE, Government Entomologist :—7 *Stomoxys*, 7 Asilidae and prey, 3 other Diptera, 43 Coleoptera, 31 Hymenoptera, 41 Lepidoptera, 40 Thysanoptera, 17 Rhynchota, and 503 Orthoptera ; from Tanganyika Territory.

Mr. H. W. SIMMONDS, Government Entomologist :—4 Diptera, 3 Coleoptera, 9 Hymenoptera, 7 Lepidoptera, and 2 species of Coccidae ; from Fiji Islands.

Mr. H. J. SNELL :—123 Diptera, 97 Coleoptera, 116 Hymenoptera, 27 Rhynchota, 40 Orthoptera, 2 Odonata, and 2 Mites ; from Zanzibar.

Dr. V. G. L. van SOMEREN :—20 Culicidae and 3 larvae ; from Kenya Colony.

Mr. O. THEODOR :—19 Diptera, 91 Coleoptera, 2 Hymenoptera, 4 Rhynchota, and 2 Orthoptera ; from Palestine.

Mr. A. THÉRY :—127 Orthoptera ; from French Congo.

Mr. H. P. THOMASSET :—15 Culicidae, 14 Tabanidae, 458 other Diptera, 304 Coleoptera, 268 Hymenoptera, 269 Lepidoptera, 15 species of Aphidae, 247 other Rhynchota, 42 Orthoptera, 4 Odonata, 7 Planipennia and 2 larvae, 2 Ephemeridae, and 6 Trichoptera ; from Natal.

VIENNA MUSEUM :—95 Orthoptera ; from Africa.

Prof. J. WAGNER :—69 Orthoptera ; from Jugo-Slavia.

WELLCOME TROPICAL RESEARCH LABORATORIES :—31 Diptera, 173 Coleoptera, 40 Parasitic Hymenoptera, 3 Lepidoptera, 150 Rhynchota, 110 Ticks, and 2 tubes of worms ; from British Sudan.

Mr. D. S. WILKINSON, Government Entomologist :—22 Coleoptera, 24 Lepidoptera, and 84 Isoptera ; from Cyprus.

Dr. W. A. YOUNG :—22 *Glossina* and 227 puparia ; from the Gold Coast.

Don VITO ZANON :—59 Orthoptera ; from Italy.

ZOOLOGICAL MUSEUM, BERLIN :—26 Orthoptera ; from Germany.

SOME TACHINIDAE (DIPT.) OF ECONOMIC IMPORTANCE FROM THE FEDERATED MALAY STATES.

By PROF. M. BEZZI,
Turin, Italy.

I am indebted to Dr. Guy A. K. Marshall for a small but important collection of Tachinid flies from the Federated Malay States, mostly parasites of insects of agricultural importance.

The examination of this material has even more convinced me that in the study of these difficult Diptera the following facts must be given the fullest consideration:—

1. *Numerous palaearctic species of TACHINIDAE, chiefly Mediterranean, are present in the Oriental Region, or are represented by closely related forms.* In relation to this fact it may be suggested that the best aid for a quick and easy determination of European TACHINIDAE is the recently published posthumous work of Prof. Paul Stein;* Dr. Villeneuve's recent paper† is very useful for affinities and new criteria of general classification; and my catalogue‡ is indispensable.

2. *Several of the known Oriental species seem to be widely spread throughout the whole Region and in Australia, and rather frequently also in the Ethiopian Region.* This is at least true for the species of economic importance, perhaps owing to the fact that their hosts have been widely distributed in the tropics through man's agency.

3. *Most of the higher TACHINIDAE, chiefly STURMIINAE, EXORISTINAE, PHOROCFRATINAE, TACHININAE, etc., seem to be polyphagous in the larval stage, and particularly those parasitic on Lepidopterous larvae.* Thus ethological data should be carefully preserved for the purpose of determining bred specimens. The puparia, when available, must be described, as they show very evident distinctive characters, as is to be seen from Ch. T. Greene's recent paper.§

4. *Numerous species of the higher TACHINIDAE show in the adult stage the most deceptive inter-resemblances, and on a superficial examination they can very easily be mistaken one for the other.* And this may be the more misleading because species in which the adults are of very like facies have often very different habits. The greatest attention must therefore be paid to such minute characters as ocellar, vertical, prevertical, orbital, frontal or facial bristles; position of vibrissae; chaetotaxy of thorax, scutellum and abdomen; position of abdominal sternites; male and female genitalia; bristles of legs; shape of pulvilli and claws; costal spine and bristles on wing-veins; minor details of venation, etc.

5. *There are already names for many species in the old writings of authors of the last century, like those of Wiedemann, Robineau-Desvoidy, Macquart, Walker, Doleschall, Rondani, Bigot, Van der Wulp, and Brauer & Bergenstamm.* These

* Die verbreitetsten Tachiniden Mitteleuropas nach ihren Gattungen und Arten.—Archiv. für Naturgesch., Berlin 1924, 90 Jahrg., Abt. A, 6 Heft, 271 pp.

† Contribution à la classification des "Tachinidae" paléarctiques.—Ann. Sci. Nat., Zoologie, (10) vii, 1924, pp. 5-39.

‡ Katalóg der palaarktischen Dipteren. Band iii. Budapest 1907. The Tachinidae, pp. 189-597, were compiled by the author of the present paper.

§ An illustrated Synopsis of the Puparia of 100 Muscoid Flies (Diptera).—Proc. U.S. Nat. Museum, Washington 1921, lx, pp. 1-39, pls. 1-20.

may be seen in Van der Wulp's catalogue of 1896, with the additions and corrections published in 1899, and concerning the types of Walker's numerous species the paper by Major E. E. Austen* is indispensable.

Subfamily STURMIINAE.

1. *Sturmia sericariae*, Cornalia (1870) ; Bezzi, Kat. pal. Dipt., iii, p. 225 (1907).

Easily distinguishable by the bare eyes, broad peristomalia, larger vibrissae considerably above the mouth-border, no bristles on the first two abdominal segments, legs with densely pennate hind tibiae and with long claws in the male, wings destitute of appendix at bend of fourth vein, with 2-3 hairs only at extreme base of third vein and anterobasally infuscated.

1 ♂, Malay Pen., Kuala Lumpur, 25.v.1924 (*G. H. Corbett & B. A. R. Gater*).

This is the well-known parasite of the silk-worm and is widely spread throughout the Oriental Region ; Prof. C. F. Baker has found it common in the Philippines.

For a description and figures of the puparium see Sasaki's paper of 1886, pl. 5, fig. 7.

2. *Sturmia atropivora*, Robineau-Desvoidy (1830) ; Bezzi, Kat. pal. Dipt., iii, p. 226 (1907).

Distinguished by the minor additional bristles at the sides of the frontal ones, the black palpi and by the thin short apical scutellar bristles.

Numerous specimens of both sexes from Malay Pen., Serdang and Stapak, parasites of various undetermined hosts (*G. H. Corbett & B. A. R. Gater*).

This European species, not hitherto recorded from the Orient under the present name, is widely spread throughout the whole Ethiopian Region, as stated by Dr. Villeneuve (*Rev. zool. afric.*, iii, 1913, p. 29, and *Ann. Soc. ent. France*, lxxxvi, 1918, p. 504).

3. *Sturmia inconspicua*, Meigen (1830) ; *bimaculata*, Hartig, Bezzi, Kat. pal. Dipt., iii, p. 226 ; *imberbis*, Wiedemann (1830) ; *idonea*, Brauer & Bergenstamm (1891).

Distinct from the preceding species by the thin ocellar bristles, which are placed at the sides and not in front of the anterior ocellus, and by the haired, not bristly, parafrontalia.

1 ♂, Malay Pen., Kuala Lumpur, 20.vi.1922, parasite of *Amathusia phidippus* (*G. H. Corbett & B. A. R. Gater*) ; 2 ♀, Kedah, 24.xii.1923, parasite of *Tiracola plagiata*, same collectors. Recorded from India under the name of *bimaculata* as a parasite of *Spodoptera mauritia*, Boisd. (Ballard, 1921) ; and also from the whole Ethiopian Region (Villeneuve, *Rev. zool. afric.*, iii, 1913, p. 29), from Madagascar (Villeneuve, *op. cit.*, iv, 1914, p. 192), and from the Seychelles Islands (Bezzi, *Parasitology*, xv, 1923, p. 102).

4. *Sturmia parachrysops*, sp. n. ♂♀.

A small species, for which I have found no available description ; *aurifrons*, Doleschall (1859), is of much larger size and has even the face golden ; *zetterstedti*, B. B., and Van der Wulp (1893), has black palpi and a quite different abdominal

* The synonymy and generic position of certain species of Muscidae (sens. lat.) in the collection of the British Museum, described by the late Francis Walker.—*Ann. Mag. N.H.* (7) xix, 1907, pp. 326-347.

pattern. The species here described as new is distinguished by the well-developed ocellar bristles, quite bare parafacialia, parafrontalia golden interiorly, reddish palpi and partly reddish antennae. Type ♂, type ♀, and 2 additional specimens from F.M.S., Kuala Lumpur, 20.vi.1923, parasitic on *Psara bipunctalis* (G. H. Corbett & B. A. R. Gater).

♂♀. Length of body 5.5–6 mm.; of wing 5–5.5 mm.

Frons of male half as broad as one eye, that of female as broad as one eye; it is clothed with whitish dust, the narrow middle stripe is deep black and the parafrontalia are clothed with golden dust near the stripe, more broadly in female than in male; in both the sexes the middle stripe is much narrower than one of the parafrontalia. Ocellar bristles rather short and thin, placed very near the anterior ocellus; outer vertical bristles less developed or indistinct in the male, strong in the female; both sexes with two pairs of preverticals directed backwards; female with two strong orbitals; no additional bristles outside of the 2–3 frontals, which extend to the base of third antennal joint. Antennae inserted considerably above the middle of the eyes, shorter than the face, with the third joint three times as long as the second and obtuse at the apex; they are black, but the second joint and the third interiorly at base are reddish; arista thickened about to the middle, with the basal joints indistinct. Eyes narrow, quite bare. Parafacialia and face entirely clothed with shining white dust, the former quite bare even above; vibrissae at mouth-edge, and above them only 2–4 bristly hairs. Peristomialia narrow, only a little broader than the third antennal joint, white-dusted and clothed with white hairs, like those of lower part of head. Palpi entirely yellowish; proboscis short, blackish. Thorax entirely black; back of mesonotum grey-dusted, with 4 very narrow black stripes; 2 presutural acrostichals and 4 postsutural dorsocentrals; 2:2 sternopleurals. Scutellum broadly reddish at hind border, with 3 pairs of laterals, with one discoidal and with the apicals small, short, decussate, rather elevated. Calypters white, the lower one very broad and bare on disc; halteres yellowish. Abdomen black above, broadly reddish at sides and below, but densely clothed with grey dust; first segment entirely shining black; second and third with a shining black band at hind border; fourth entirely grey; first segment without bristles, second with a middle pair at hind border, third with a complete row; all the hairs black. Third central segment of male with lateral, black-haired, rounded depressions, but less striking than in other species of the section *Zygobothria*; male genitalia small and hidden. Legs entirely black; hind tibiae with thin and not dense, but well-developed ciliation; claws and pulvelli of male twice as long as those of female. Wings hyaline, with the veins pale yellowish at base; bend of fourth vein an obtuse angle, almost rounded; apical cross-vein nearly straight and parallel with the hind one; first posterior cell narrowly open; all the veins bare, the third with only one bristle at extreme base.

5. *Winthemia semiberbis*, sp. n. ♂♀.

This is a true *Winthemia* with only two sterno-pleural bristles, but differs from the other species in the more ascending vibrissae and in the not decussate apical scutellar bristles. In the short front claws of the male the species recalls those of the genus *Sericophoromyia*, Austen, but differs in the other characters; the haired but not bristly parafacialia distinguish it from *Chaetosturmia*, Villeneuve (1914).

Type ♂ and type ♀ from Kuala Lumpur, iv.1921, parasitic on *Sesamia inferens* (G. H. Corbett & B. A. R. Gater). Additional specimens of both sexes from Malay Pen., Stapak and Kudong, same collectors; other specimens from Kudong, parasitic on *Sesamia* or Padi borer (*L. Lewton Brain*).

♂♀. Length of body 8.9 mm.; of wing 6.5–7.5 mm.

Occiput black, grey-dusted, with long whitish hairs in the middle and with a row of short, thin, black cilia at border. Frons of male half as broad as one eye, that of female as broad as one eye; middle stripe deep black or reddish brown, gradually broadened forwards, in the male about as broad as one of the parafrontalia, but at vertex much narrower, in the female narrower than one of the parafrontalia; ocellar triangle greyish; parafrontalia grey-dusted and with black hairs inside. Ocellar bristles strong and long; both sexes with 2 verticals and with 2 preverticals directed backwards; female with 2 orbitals; 2-3 frontals descending to the middle of second antennal joint. Eyes narrow, densely pilose. Parafacialia grey-dusted, as broad as or a little broader than the third antennal joint, clothed on their whole length with numerous, rather thick black hairs; facial ridges with 6-7 bristly hairs ascending to the middle of face; face black, grey-dusted, a little reddish below; peristomialia grey-dusted, with reddish subocular spot, about as broad as one-fifth of vertical diameter of eye, clothed with black hairs. Antennae inserted about at middle of eyes; second joint elongated entirely reddish, with thick black bristly hairs; third joint twice as long as the second, blackish, linear, truncate at end; arista bare, as long as the whole antenna, thickened on basal third, with short basal joint. Palpi clavate, entirely reddish; proboscis short, black. Thorax black, with reddish humeral and postalar callosities; the back is grey-dusted, with 4 narrow black stripes; pleurae black, grey-dusted, with somewhat reddish sutures; sternopleurals 1:1; 3 presutural acrostichals, 4 postsutural dorsocentrals and 1 presutural intra-alar; all the hairs and bristles black. Scutellum reddish, grey-dusted, with narrow black base; 3 laterals, 1 discal, apical small, diverging, slightly elevated. Calypters whitish, the lower one greatly developed and bare on disc; halteres with blackish knob. Abdomen shining black, in the male with sides of second and third segments more or less broadly reddish; 2nd, 3rd and 4th segments with broad basal band of whitish dust, and narrow black middle stripe; hairs and bristles black, no discals, first and second segments without middle bristles at hind border, third and fourth with a complete row; venter of male without rounded fasciculate spots (and thus differing from *W. fasciculata*, Villen. 1921); genitalia small and hidden. Legs entirely black; pulvilli and claws of male less elongated; hind tibiae with long, dense, equal ciliation. Wings quite hyaline, iridescent, with yellowish veins; venation normal; first vein bare, third with 1-2 bristles at extreme base; apical cross-vein deeply concave, bend of fourth vein at right angle; hind cross-vein more oblique than the apical one. No costal spine.

Puparium.—Length 8 mm.; diameter 3 mm. Medium-sized, regularly cylindrical, reddish, subshining, with indistinct segmentation and no punctuation near the sutures. Spiracles placed on longitudinal axis, small, faintly raised above the surface, contiguous, shining black; button very small. Just below the spiracles and in contact with them there is a prominent elevation, rounded, brownish, a little larger than one of the stigmal plates. Anal opening small, far below the spiracles.

This puparium differs from that of *Winthemia quadripustulata*, as described by Greene (p. 33, pl. 20, fig. 95), chiefly in the presence of the elevation below the spiracles, and in the plates not being separated.

6. *Carcelia modicella*, Van der Wulp, Tijds. v. Ent., xxxvi, 1893, p. 178, pl. 6, fig. 2 (*Paraxorista*).

Nearly allied to the European *gnava*, Meig., but distinguished by the pattern of the abdomen, the hind border of the middle segments being broadly black.

Both sexes, Malay Pen., Kuala Lumpur, 25.iv.1924, parasite of undetermined larva (G. H. Corbett & B. A. R. Gater); Johore, viii 1922 (G. H. Corbett).

Originally described from Java, bred from *Macroglossa belia*, Cr., from *Ophideres fullonica*, L., and from *Dasychira grossa*, Snell.; I have also received Javanese specimens through Dr. R. Menzel. *C. gnava*, Meig., is recorded from Ceylon (Hutson 1922) as bred from *Caprinia conchylalis* and *Stauropus alternus*.

Subfamily EXORISTINAE.

7. *Chaetoxorista javana*, Brauer & Bergenstamm, Denkschr. K. Akad. Wiss. Wien, lxi, 1894, p. 616.

Easily to be mistaken for *Tricholyga sorbillans*, Wied., inasmuch as the male shows also a yellow tuft on the genitalia, but distinct by the frontal bristles descending only to the base of third antennal joint and there being rather distant from the facial ridges, by the much narrower black stripes of back of mesonotum, by the third vein being bristly from base to the small cross-vein, and chiefly by the truncate claws of anterior legs in the male.

2 ♂ 1 ♀ Malay Pen., Carey Island, 25.vii.1923, parasite of *Setora nitens* (G. H. Corbett & B. A. R. Gater).

I have also received this species from Java from Dr. Menzel, bred from *Thosea* sp. (see De Thee, iv, 1923, p. 3). The species is recorded even from Japan as a parasite of *Cnidocampa flavescens*, Walk., and is proposed for importation into North America (see J. N. Summers, Journ. Econ. Ent., xvi, 1923, p. 292). This species cannot be placed in the STURMIINAE, the female not having pennate hind tibiae; a complete description of it is appended here.

♂♀. Length of body 11–13 mm.; of wing 9–10 mm.

Head black; occiput densely grey-dusted, clothed with long dense whitish hairs, and with a double row of thin black cilia at border. Frons rather prominent in profile, in the male as broad as half of one eye, in the female as broad as one eye; middle stripe deep black, gradually broadening forwards, in the male a little narrower, in the female much narrower than one of the parafrontalia; these latter grey-dusted, with scattered black hairs, which are stouter in the male, passing to small bristles in front; ocellar triangle grey, black-haired; lunula shining black. Ocellar bristles strong; no outer vertical in the male and one very small in the female; 2 preverticals curved behind in both sexes; 2 strong orbitals in the female; descending frontals 3–4, but not extending beyond base of third antennal joint and placed on a line directed outwardly (instead of being parallel to the facial ridges). Eyes narrow, densely haired. Antennae inserted above middle of eyes, entirely black; third joint three times as long as the second, gradually dilated towards end and truncate; arista longer than the whole antenna, bare, thickened in the basal third, hair-like in the rest, with the basal joint very small. Face and parafacialia white-dusted, the latter quite bare even above, in the female as broad as, in the male narrower than, the third antennal joint; middle keel small but distinct; mouth-border very little prominent; vibrissae at mouth-edge, and above them 6–8 bristly hairs ascending to the middle of facial ridges. Peristomialia one-fifth of vertical diameter of eye, dark grey-dusted, with brownish subocular spot, clothed with dark hairs, but the hairs at lower border of head whitish. Palpi thick and long, reddish on terminal half, black on basal half, black-haired; proboscis short, with the basal half shining black. Thorax entirely black; back of mesonotum dark grey-dusted; with 4 narrow black stripes, the middle ones much narrower than the others; hairs and bristles black; 3 presuturals and 3 postsutural acrostichals; 4 postsutural dorsocentrals; 1 presutural intra-alar; sternopleurals 2:1, but the lower interior one very small. Scutellum shining black, grey-dusted at sides and behind, with 3 laterals, 1 discal and 1 strong apical, horizontal and decussate. Calypters whitish, the lower one greatly developed and bare on disc; halteres small, yellowish. Abdomen broad, shining black, with the 2 middle segments more or less broadly reddish at sides; first segment entirely black; second and third grey-dusted, with narrow black middle stripe and rather broad black hind border; fourth segment grey. Venter shining black, with the base of each segment broadly white-dusted. No discoidal bristles; first and second segments with one middle pair at hind border, those of the second much stronger. Male genitalia aculeate, shining black, with

a tuft of yellow hairs at base of central point; venter of male without foveae, but the end of abdomen, chiefly on venter, is clothed with dense long black hairs. Female genitalia with a prominent lower lamella which has a thick, shining black, smooth hind border and with a median shining black rounded tubercle. Legs entirely black; hind tibiae of male densely and evenly ciliated, while those of female are beset with unequal bristles; anterior legs of male with very long pulvilli, but with truncated claws, which are much shorter than the pulvilli; hind legs of male with acute claws, as long as pulvilli; female with undilated front tarsi and with all the claws acute, curved and a little longer than the short pulvilli. Wings hyaline, iridescent, a little darkened at base and fore border. No costal spine; first vein bare, third with 6-7 spines extending from base to a little before the small cross-vein, and even on the underside with 3-4 smaller black spines; apical cross-vein concave, the bend at a right angle, with short but distinct, spurious appendix; small cross-vein before middle of discal cell; hind cross-vein long, oblique, broadly S-shaped and parallel with the apical one.

Puparium.—That from *Thosea* in my collection. It is enclosed in the cocoon of the host; the cocoon being nearly sphaeroidal, the puparium of the parasite is located along one diameter, with the anterior end adjoining the large round exit hole, while the posterior end is applied to the opposite side. Length 9 mm., diameter 4 mm. Very large, cylindrical, thin, fragile, light reddish, smooth, shining; segmentation well marked by one row of short lines, the fine punctuation in 3 rows being exceedingly minute. Posterior end bluntly conical, rather elevated. Spiracles raised, small, shining black, rounded; they are located considerably above longitudinal axis and separated by a space as broad as the diameter of one of the plates; this space is impressed to form a rather deep furrow, which ends below in a circular depression, about mid-way between the spiracles and the elevated posterior end. Button very small; anal opening far below the conical elevation, which is nearly on the longitudinal axis.

8. *Exorista laeiventris*, Van der Wulp, Tijds. v. Ent., xxxvi, 1893, p. 173, pl. v, fig. 4 (*Parexorista*).

Described from Java and distinguished by the shining black abdomen, which has only narrow basal whitish bands on second and third segments.

1 ♂, Malay Pen., Kuala Lumpur, 26.vii.1921; 1 ♀, 13.i.1921; parasite of *Hemithea costipunctata* (G. H. Corbett & B. A. R. Gater).

The male has no external vertical bristles and but one prevertical; ocellars strong; only two descending frontals; parafacialia very narrow and quite bare; vibrissae at mouth-edge, with 1-2 hairs above; palpi black; 2 presutural acrostichals and 4 postsutural dorsocentrals; only 2 sternopleurals (scutellum damaged in the single specimen); second abdominal segment with one median pair at hind border; front claws elongate; hind tibiae with irregular ciliation; third vein with two bristles at extreme base.

The, as yet, undescribed female is very like the male, with the frons not much broader, the middle stripe being equal to that of the male; parafacialia about as broad as the middle stripe, while in the male they are about half as broad; hind tibiae not ciliated; pulvilli and claws very short.

Puparium.—Length 5 mm.; diameter 2 mm. Small, shining red, smooth, with well-marked segmentation. Spiracles shining black, raised above surface, closely approximate, with small button; they are placed on the longitudinal axis. Just below the plates and in contact with them there is a rounded tubercle, with a depression at apex. Anal opening small, far below the spiracles.

9. *Exorista corvinoides*, Van der Wulp, var. *rufella* nov. ♀.

A small species, very distinct on account of its rufous abdomen, which, however, is broadly black on the last two segments in the female.

Described from Java, bred from *Liparis corticea*, Sn. (Tijds. v. Ent., xxxvi, 1893, p. 170, pl. v, fig. 2). There are 4 ♀♀ from Kuala Lumpur, May 1922, parasitic on *Chalcoscelis fumifera*, Swinh. The new variety is distinct in having the antennae broadly reddish at base, the middle frontal stripe also reddish and the abdomen darker, like the 4 posterior tibiae. Ocellars strong; 2 verticals and 2 preverticals; 2 descending frontals; only 1-2 pairs above vibrissae; 2 presutural acrostichals and 3 (sometimes 4) postsutural dorsocentrals; 1 presutural intra-alar, 3 sternopleurals, 2:1; apical scutellars small and decussate; second abdominal segment with one middle pair at hind border; hind tibiae not ciliated; claws and pulvilli small; third vein with no bristles at base; apical cross-vein long, oblique, concave, the first posterior cell narrowly open; costal spine small, but distinct.

10. *Erycia basifulva*, sp. n. ♂♀.

Belonging to *Hemimasicera* as recently interpreted by Prof. Stein and allied to *vicina*, Zett. (*gyrovaga*, Rond.) on account of the absence of ocellar bristles, but distinct by the presence of only 2 (not 4) sternopleural bristles, by the absence of bristly hairs beside the frontal bristles, and by the yellow calypters and the yellow base to the wings. In this last character the species agrees with *Ceromasia ferruginea*, Meig. (*rutila*, Meig., Stein), which, however, has strong ocellar bristles, 3 sternopleurals, discal abdominal bristles, yellowish tibiae, etc.

Types ♂♀ and additional specimens of both sexes from Malay Pen., Carey Island and Kuala Lumpur, parasitic on *Tirathaba trichogramma* (G. H. Corbett & B. A. R. Gater).

♂♀. Length of body 7-8 mm.; of wing 5.5-6 mm.

Occiput black, grey-dusted, clothed with dark yellowish hairs and with one row of thin black cilia at border. Frons of female only a little broader than that of male and in both narrower than one eye; middle stripe deep black, with about parallel sides, in the male as broad as, in the female a little narrower than, one of the parafrontalia; these latter are white-dusted and clothed with thin black hairs; no ocellar bristles; both sexes with only the inner pair of verticals and with two pairs of preverticals directed backward; female with 2 strong orbitals; 2-3 frontals descending below the lunula and not reaching the end of second antennal joint. Eyes narrow in profile and quite bare. Antennae inserted a little below the middle of the eyes and rather short; the two basal joints are reddish, the second short and beset with black setulae; third joint black, $2\frac{1}{2}$ times the second, parallel-sided, obtuse at end; arista bare, longer than the whole antenna, thickened on less than the basal half, with the basal joints not distinct. Parafacialia white-dusted, quite bare, narrow, in the male even narrower than the third antennal joint; face concave, without middle keel, dark grey-dusted, somewhat reddish above the mouth-border; vibrissae at mouth-edge, with 3-6 short bristly hairs above them; mouth-border not prominent; peristomialia narrow, not broader than the third antennal joint, whitish-dusted with a reddish-brown line just below eye, clothed with black hairs, even the hairs of lower part of occiput being black. Palpi clavate, entirely reddish, black-haired; proboscis short, thick, dirty reddish at end. Thorax entirely black, dark grey-dusted on the back and there with 4 narrow black stripes, the lateral ones being broader and interrupted at suture; scutellum entirely black, dark grey-dusted; 2 presutural acrostichals, 4 postsutural dorsocentrals, 1 presutural intra-alar; only 2 sternopleurals; scutellum with 3 laterals, 1 discoidal, 1 small apical, decussate and oblique. Calypters bright yellow in both sexes, the lower greatly

developed and bare on disc; halteres yellow. Abdomen shining black, first segment without dust, second with a narrow basal band of grey dust, third and fourth entirely grey-dusted, only the narrow hind border of third being shining black; third ventral segment of male with small, rounded, black-haired depressions; male genitalia small, aculeate. First and second abdominal segments with one median pair of bristles at hind border, third and fourth with complete rows; no discal bristles, even on fourth segment. Legs entirely black; claws and pulvilli small and short in both sexes (in *vicina* they are elongate in the male); hind tibiae of male with scattered ciliation and with one long bristle on last third; hind tibiae of female not ciliated. Wings very short, hyaline, iridescent, with bright yellowish base; veins yellowish, narrowly infuscated at end; no costal spine; third vein with 1-2 bristles at base; first posterior cell open, ending not much before wing-tip; apical cross-vein a little concave but parallel with the hind one; small cross-vein before the middle of the discal cell and much before the end of first vein.

Puparium.—Enclosed in the cocoon of the parasitised moth. Length 6.5 mm.; diameter 3 mm. Small, regularly cylindrical, proportionately short and broad, shining reddish, smooth, with indistinct segmentation. Spiracles placed just below the longitudinal axis, raised at surface; plates shining black, rounded, separated by a distance half as long as the diameter of one plate, with small button. Between and below the plates there is a prominent, rounded, flat tubercle, dirty yellowish in colour. Anal opening small, far below the spiracles.

Subfamily PHOROCERATINAE.

11. *Ptychomyia remota*, Aldrich, Proc. Ent. Soc. Washington, xxvii, 1925, p. 13.

Distinguished by the strong ascending vibrissae and by the hind cross-vein being placed midway between the small one and the bend of fourth vein.

Numerous specimens of both sexes from Malay Pen., Sungei Ayer Jawar, 27.vii. 1924, from larvae of *Artona catoxantha*, Hamps. (G. H. Corbett & B. A. R. Gater). They agree perfectly with paratypes sent me by Dr. J. M. Aldrich of the U.S. National Museum; and also with specimens received from Java through Mr. S. Leefmans and likewise bred from larvae of the same Zygaenid moth.

This species is very like the European *selecta*, Meig., differing chiefly in lacking the discal macrochaetae of 3rd abdominal segment, and moreover, in the distinctly narrower frons of the male, in the quite black palpi and in the golden-dusted parafacialia. The dust of back of mesonotum is more yellowish in both sexes, while in both sexes of *selecta* it is whitish.

12. *Podomyia setosa*, Doleschall (1859).

Distinct from the other species by the robust body, strong macrochaetae, ascending vibrissae, hairy frons, rather distant eyes of male, bare parafacialia, ciliated hind tibiae and short claws of male.

1 ♂, F.M.S., Kajang, v.1921, from larvae of *Prodenia litura* (G. H. Corbett & B. A. R. Gater). Widely spread over the Oriental Region, as I have seen it from the Philippines (Prof. C. F. Baker).

Subfamily TACHININAE.

13. *Tricholyga sorbillans*, Wiedemann (1830); *grandis* & *pavoniae*, Zetterstedt (1844); *major*, Rondani (1859); *lasiommata*, Loew (1870); *bombycum*, Becker (1899).

Very distinct from the other species of the genus on account of the golden tuft on the male genitalia.

Numerous specimens, chiefly males, from Malay Pen., Kuala Lumpur, Kajang and Serdang, parasitic on *Amathusia phidippus* and *Notolophus posticus*.

Even this parasite of the silkworm is spread throughout the whole Oriental Region (Broquet & Villeneuve, Bull. Soc. path. exot., iii, 1910, p. 766, and Villeneuve, Zeits. wiss. Insektenbiol., xv, 1910, p. 395), and also in the Ethiopian Region (Villeneuve, Rev. zool. afric., iii, 1913, p. 34). I have seen specimens from Java, from Canton and from the Philippines. For figures of the puparium see Menzel (De Thee, iii, 1922, pl. xv, fig. 1), parasite of *Andraca bipunctata*; in Ceylon it has been bred from *Notolophus posticus* (see Hutson's Report 1922, p. 25), and in India from silkworms (see Jameson's Report 1922). Besides the genus *Podotachina*, Brauer & Bergenstamm (1891), the genus *Neoscotia* was proposed for the present species by Tyler Townsend (Proc. U.S. Nat. Mus., 1919, p. 579).

14. *Tricholyga aberrans*, Strobl 1893 (*Pokornya*); *deligata*, Pandelli 1896 (*Exorista*).

Some specimens of both sexes from Malay Pen., Carey Island, parasitic on *Mahasena* sp. and on *Amathusia phidippus* (G. H. Corbett & B. A. R. Gater).

This Mediterranean species was believed to be very rare; but it seems widely spread (see Villeneuve, Bull. Soc. ent. France, 1916, p. 260).

These specimens have only 4 descending frontal bristles and the first posterior cell narrowly open.

Subfamily THELAIRIINAE.

15. *Halidaya luteicornis*, Walker, Proc. Linn. Soc. London, vi, 1861, p. 10 (*Gymnostylia*); Austen, Ann. Mag. N.H. (7) xix, 1907, p. 346.

Very like the European *H. argentea*, but at once distinguished by the entirely reddish abdomen.

Several specimens of both sexes from Malaya, Taiping, i.1922, parasitic on *Parnara mathias*; Malacca, 7.xi.1923; Seremban, x.1921 (G. H. Corbett & B. A. R. Gater).

Originally described from Gilolo, but apparently widely spread in the Orient, as I have received specimens from Canton (C. W. Howard), and have seen others from Hangchow in the U.S. Nat. Museum, collected by H. A. Jaynes.

This is an important discovery, the species of *Halidaya* being very rare in Europe (in 40 years' collecting I have never met with them and have seen only specimens collected by L. Oldenberg) and having never been reared. In the Catalogue of Palearctic Diptera, iii, p. 463, I have used the name *Clytho*, following Haliday; but now I am convinced that Stein is right in rejecting this as a synonym.

The three known species of the genus *Halidaya* may be distinguished as follows:—

- 1 (4). Abdomen with a black median stripe and black terminal segments.
- 2 (3). Third longitudinal vein with only a few bristles at base, not extending beyond small cross-vein; fifth vein quite bare; frons and back of mesonotum clothed with golden dust *aurea*, Egg.
- 3 (2). Bristles of third vein extending beyond small cross-vein; fifth vein with some bristles at base; frons and back with silvery dust *argentea*, Egg.
- 4 (1). Abdomen entirely reddish; frons, back and wings as in *argentea*
luteicornis, Walk.

A complete description of this last species is appended here, together with that of the puparium.

♂♀. Length of body 6.5–7.5 mm.; of wing 5–6 mm.

Head as in *argentea*. Occiput clothed with whitish dust, silvery at eye-borders, and there with a complete marginal row of short black bristles. Frons equally broad in both sexes, parallel-sided, more than twice as long as the face; parafrontalia argenteous; middle stripe unusually narrow, nearly linear, deep black, a little dilated behind and in front for reception of greyish ocellar triangle and of greyish lunula; frontal bristles not extending beyond the lunula and with 3-4 preverticals directed backward, the other 3-5 directed inward and decussate; both sexes with complete rows of 5-6 orbitals, all directed forward; ocellars very thin, hardly distinguishable; only the inner vertical present in both sexes. Eyes bare, rounded, flat, forming the whole head in profile, the frons being not at all prominent. Antennae inserted very low, approximated, short, not reaching the mouth-border, quite yellowish; third joint rounded at end, not quite twice as long as the second; arista bare, thickened at base and there reddish, about twice as long as the whole antenna. Face very short, densely clothed with silvery dust like the parafacialia, which are quite bare and much narrowed below; no middle keel and no prominent mouth-border. Peristomialia linear, argenteous; vibrissae at mouth-edge, with one bristly hair above and another below, the vibrissae being long and decussate; a strong marginal bristle in middle of lower border of head and some bristly hairs behind it. The short proboscis and the palpi pale yellowish. Thorax black, clothed with argenteous dust on back and even more on pleurae; on the back there are 4 black longitudinal stripes; 2 presuturals and 3 postsutural dorso-centrals; 3 presutural acrostichals; only one strong posterior sternopleural, and before this a much smaller one. Scutellum black, grey-dusted; 2 pairs of laterals and one pair of decussate apicals, thin and much shorter than the long and diverging subapicals. Calypters whitish, the lower one very greatly developed and bare on disc; halteres pale yellowish. Abdomen entirely reddish, except a small black spot at base of first segment just below the scutellum, and a small black hind border on fourth segment, sometimes quite wanting; chaetotaxy as in *argentea*, third segment with a complete row at hind border, fourth with two complete rows, one of which is discoidal; the ventral part of tergites has one pair of strong bristles at hind border of second segment, in the middle of venter. Male genitalia very small, concealed. Coxae and legs entirely yellowish, only the tarsi black. Wings as in *argentea*; first vein bristly throughout its whole length; third bristly to the hind cross-vein; fifth with 2-4 bristles at base.

Puparium.—Length 5.5-6 mm.; diameter 1.7-2 mm. Small, elongate, becoming gradually smaller toward the caudal end, smooth, shining, dark reddish-brown to nearly black. Segmentation distinct, but not much marked. Spiracles on the longitudinal axis, a little below the line; they are tuberculate and very prominent, shining black, closely approximate at base and more distant toward the apex; they are punctulate at base, smooth on terminal portion, which is rounded at end; stigmal plates at top interiorly, with very small slits and button. Anal opening small, on the underside of puparium, its distance from the spiracles greater than the length of one tubercle. Anterior spiracles well developed, shining black, rotundate, tuberculate and widely separated; they are about half the size of the posterior ones.

Subfamily PSEUDOCYPTERINAE.

16. *Pseudocrypta erythroga*, sp. n. ♂.

Closely allied to the type-species *obscura*, B.B., but at once distinguishable by the reddish antennae and femora.

Type ♂ a solitary specimen from Malay Pen., Stapak, 15.i.1924 (G. H. Corbett & B. A. R. Gater).

♂. Length of body 6.5 mm.; of wing 5 mm. Head black; occiput convex, white-dusted at sides and below, with short black hairs in middle above neck, and with a row of bristly hairs at eye-borders. Frons as broad as one eye, a little broadened forwards; parafrontalia shining black, but in part clothed with dense whitish dust; middle stripe deep black, broader than one of the parafrontalia; ocellar spot rounded, greyish; 5-6 thin and short frontal bristles; ocellars very thin; verticals strong and thick. Eyes rather narrow, bare. Antennae inserted much above the middle of eyes, rather long and extending to the mouth-border; third joint three times as long as the second, distinctly dilated toward the end, rounded at tip; all the joints entirely reddish; arista bare, as long as the whole antenna, reddish, with distinct basal joint. Face longer than the frons, flat, without middle keel and with no prominent mouth-border; it is argenteous, like the narrow and bare parafacialia. Peristomialia as broad as half the vertical diameter of head, reddish but clothed with silvery dust. Vibrissae at mouth-edge, very long and decussate; above them 1 and below them 3-4 short black bristly hairs. Palpi well developed, thin but clavate, pale reddish; proboscis short and thick, blackish. Thorax entirely black, with whitish dust, on the back with 4 black stripes, the middle ones narrower; on the pleurae there are white stripes above the coxae. Scutellum black, subquadrate; bristles damaged in type, only 3 hypopleurals. Calypters whitish, the lower one greatly developed and bare on disc; halteres white. Abdomen shining black; second and third segments with a broad, complete basal band of whitish dust, extending even to the ventral part of tergites. Bristles only marginal, placed in middle of hind border and at sides, even on first segment. Genitalia rounded, provided below with a strong black spine on each side at base. Coxae black, white-dusted; trochanters and femora reddish; tibiae and tarsi black, but those of hind pair in part dark yellowish; claws long; front femora a little thickened. Wings greyish-hyaline, a little darkened on anterior half. All the veins bare; bend of fourth rather rounded, apical cross-vein as long as the hind one; terminal stalk of first posterior cell a little longer than half the apical cross-vein; small cross-vein a little before the middle of the discoidal cell; hind cross-vein straight, but placed obliquely and parallel with the apical one; sixth vein not reaching hind border.

Puparium.—Length 4.5 mm.; diameter 2 mm. Small, regularly oval, dull, dark red, smooth, with indistinct segmentation. Posterior spiracles placed on two very broad, rounded, convex, shining black prominences, placed on the longitudinal axis, but mostly below the line; they are in contact along an extended deep line. Plates very small, rounded, distant. Anal opening far below the spiracles, on ventral surface of puparium.

ON SOME TROPICAL THYSANOPTERA.

By H. H. KARNY,
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The following paper deals with a collection of Thysanoptera from various tropical countries, but especially Africa, received by the author from the Imperial Bureau of Entomology for determination. As most of the species before me are from new localities or from new food-plants, I have thought it desirable to give the data not only for the new species, but for all the others also.

It gives me great pleasure to acknowledge my indebtedness to Drs. Guy A. K. Marshall and S. A. Neave for the opportunity of studying this important material.

TERIBRANTIA.

Heliothrips haemorrhoidalis (Bouché).

Five specimens, with numerous *Dinurothrips hookeri*, on *Solanum* creeper, Mandeville, Jamaica, 15 ii.1921 (C. C. Gowdey).

One ♀, with a dozen *Selenothrips rubrocinctus*, on cacao, Belgian Congo (R. Mayné). Uganda, with a few *Retithrips aegyptiacus*, on rose leaves (H. Hargreaves).

Dinurothrips hookeri, Hood.

Seventeen specimens, with a few *Heliothrips haemorrhoidalis*, on *Solanum* creeper, Mandeville, Jamaica, 15 ii.1921 (C. C. Gowdey).

The specimens have been compared with a paratype, for which I am indebted to Mr Hood.

Retithrips aegyptiacus, Marchal.

Several specimens of all instars from Egypt (E. Hargreaves): Beni Suef, Egypt, 1.ix.1921, on *Eucalyptus*, Beni Suef, on vine and castor bean. Uganda, on rose leaves (H. Hargreaves).

Larvae and pupae bright red throughout, the latter even with the wing-cases red.

Selenothrips rubrocinctus (Giard).

Pusey Hill, Jamaica, 15.ii.1921, on mango (C. C. Gowdey).

Belgian Congo, on cacao, with one *Heliothrips haemorrhoidalis* (R. Mayné). Kampala, Uganda, 22.xii.1920 and 11.vi.1921, on cacao (H. Hargreaves).

Larvae, pupae, and newly hatched imagines with a bright red band across basal abdominal segments, which disappears in older specimens (syn. *decolor*, Karny, *mendax*, Schmutz).

Frankliniella dampfi, Priesner.

In the material before me there are a few quite yellow specimens which agree perfectly with Priesner's description. Most of the ♀♀ from Uganda, however, are coloured like *trybomi*, Karny, but differ from this Australian species by the longer and paler middle joints of antennae. They may be considered, therefore, as a colour variety of *dampfi*, corresponding to var. *melanura*, Priesner, of *pallida*.

The interocellar bristles (fig. 1) are situated in them as described by Priesner for *dampfi*, but are conspicuously longer, about as long as in *F. pallida*, and equal in length to the postocular bristles, if not longer. I name these specimens therefore subsp. *interocellaris*, nov. All other characters as in the typical *dampfi*. ♂♂ quite yellow.

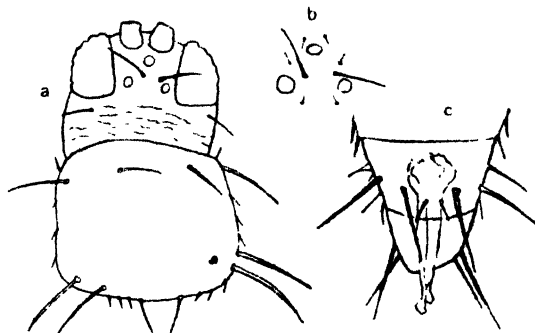


Fig. 1. *Frankliniella dampfi interocellaris*, subsp. n.: a, head and prothorax of ♀; b, ocelli and interocellar bristles, ♀; c, end of abdomen, ♂.

Typical form.—Numerous specimens from Egypt (*E. Hargreaves*), among them 1 ♀ having the left antenna quite normal, whilst the right one is of "Ceratothripid" structure. One ♀, Kampala, Uganda, from flowers, 16.xii.1920 (*H. Hargreaves*), with some *Physothrips ventralis*.

Subsp. *interocellaris*. One ♀, with numerous specimens of the typical form, from Egypt (*E. Hargreaves*). A few ♂♂ and ♀♀, on flower of *Ipomoea hildebrandti*, 26.xii.1920, on flower of karandalujo, 6.i.1921, on flowers of kinguramuti, 9.ii.1923, on cotton flowers, 24.ii.1923, Kampala, Uganda (*H. Hargreaves*).

Taeniothrips longistylus, Karny.

On flowers of *Crotalaria striata*, 3.viii.1920, Fiji (*W. Greenwood*).

Hitherto known from Siam, Indo-china, and the Sunda Islands.

Physothrips sjöstedti (Trybom).

Babendi, Uganda, on flowers of *Sesbania* and *Caesalpinia*, 10.i.1923 (*H. Hargreaves*); Kampala, Uganda, on flower of kivikiti, 6.i.1921, on flowers of *Tephrosia*, ii.x.1921 (*H. Hargreaves*). Morogoro, Tanganyika Territory, iv.1922, on blossoms of *Dolichos lablab*, causing severe infestation (*A. H. Ritchie*).

About six of the specimens before me have only one fore wing normally bristled, whilst on the other the bristle row of the chief vein is not interrupted before the two apical bristles, but continuous as in *P. meruensis*. Nevertheless, I consider the latter to be a valid species, differing from *sjöstedti* also in the much shorter antennal style, which is confirmed by Trybom's figures and his cotypes in my collection.



Fig. 2. *Physothrips sjöstedti*, Tryb., apical joints of antenna.

Five of the ♀♀ show on one antenna an abnormality quite as figured for *Physothrips ventralis*, fig. 4b. The species differs from *Odontothrips karnyi*, Priesner, especially in the long, slender, not scale-shaped sense-cones of the 6th antennal joint (fig. 2), which are thus shaped in the large material before me, especially in all the specimens

(about 70) from *Dolichos lablab*. Thus, it can be stated now with certainty that not only *Odontothrips*, but also *Physothrips sjöstedti* occurs in leguminous flowers.

***Physothrips hargreavesi*, sp. n.**

♀. Dark brown; all tibiae yellow, slightly infumate basad; tarsi pale yellowish, with a dark spot. Antennae grey brown, 2nd joint paler at apex, 3rd and basal half of 4th pale, whitish yellow.

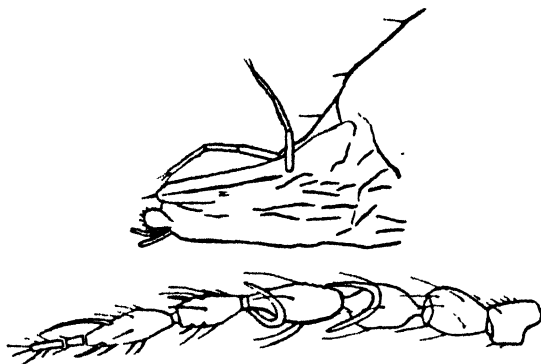


Fig. 3. *Physothrips hargreavesi*, sp. n. ♀: lateral view of mouth-cone (above), and antenna (below).

Head wider than long. Occiput transversely rugulose. Antennae (fig. 3) two and a-half times as long as head, with thick joints; 1st joint cylindrical, a little longer than wide; 2nd joint cup-shaped; 3rd joint ovate, with narrow pedicel; 4th joint ovate in basal half, widest before the middle, produced distad in the form of a narrowing stem; 5th joint short and narrow, clavate, transversely truncate at apex; 6th joint fusiform; style long and slender, basal joint shorter than the distal one; bristles rather long and strong; the usual forked sense-cones of joints 3 and 4 relatively short and thick, the simple ones of joints 5 and 6 narrow and short, except the upper sense-cone of 6, which reaches the middle of 8th segment. Mouth-cone (fig. 3) very long and slender, reaching hind margin of pronotum; maxillary palpi long and slender, 3-jointed, reaching apex of mouth-cone; labial palpi short and thin.

Pronotum with very short bristles on the whole surface, and with two long and strong ones at each posterior angle, which are about equal in length. Front legs rather short and stout. Pterothorax as long as wide, sides slightly arched and converging backwards. Sutures of mesosternum \perp -shaped, as usual, the endothoracic invaginations apposed to the longitudinal line of the \perp , being obliquely rhomboidal, directed forwards and outwards. Metasternal structures practically as in *Taeniothrips taeniatius*, but the cross line of the T-suture strongly convex backwards, rather semicircular, and the hindermost rhomb closed at the apex.

Wings reaching about base of 7th abdominal segment; fore pair uniformly greyish-brown infumate, except an obsolete pale cross-band near base; hind wings infumate, especially along median vein. Costa of fore wings with about 25 strong bristles inserted between the fringe hairs; chief vein with 5 or 6, then after a short distance 6 till a little beyond the middle, finally two close before apex; lower vein with a continuous row of 9 bristles, beginning between the 2nd and 3rd bristle of second bristle-group of chief vein, and ending near its first distal bristle. Scale with 5 bristles along fore margin, the apical one of which is by far the longest, and with 2 on disc.

Abdomen somewhat wider than pterothorax, about three times as long as wide; bristles strong and long, especially on last and penultimate segments; base of ovipositor reaching the fore margin of 8th segment; apical segment split off longitudinally, transversely truncate at apex.

Measurements (in millimetres).—♀. Total length of antennae 0.25; first joint 0.025 long, 0.02 wide; second joint 0.03 long, 0.025 wide; third joint 0.04 long; 0.022 wide; fourth joint 0.05 long, 0.02 wide; fifth joint 0.035 long, 0.015 wide; sixth joint 0.048 long, 0.018 wide; seventh joint 0.01 long, 0.004 wide; eighth joint 0.012 long, 0.003 wide. Head 0.10 long, ± 0.12 wide. Prothorax 0.12 long, ± 0.15 wide (across fore coxae). Front femora 0.10 long, 0.05 wide; front tibiae (incl. tarsi) 0.15 long, 0.03 wide. Pterothorax 0.20 long, 0.20 wide. Middle femora 0.10 long, 0.03 wide; middle tibiae (incl. tarsi) 0.14 long, 0.03 wide. Hind femora 0.10 long, 0.04 wide; hind tibiae (incl. tarsi) 0.19 long, 0.03 wide. Length of wings 0.57 (without fringe). Abdomen 0.75 long, 0.24 wide. Total length 1.1–1.2.

Named in honour of its discoverer, Mr. H. Hargreaves, Government Entomologist, Uganda.

This new species belongs by the chaetotaxy of the fore wings and by the shape of the 4th antennal joint to the *antennalis-xanthocerus* group, differing from the hitherto known species of this group by the thicker antennal joints, and by the much longer interval on the fore wings between the distal and middle groups of bristles, the latter ending close behind the middle. By this character it approaches somewhat to the *ventralis-funtumiac* group, from which it may be distinguished by the different colouration and shape of the antennal joints, especially the 4th, and by the absence of fringe hairs on the posterior margin of the 8th abdominal segment.

Two ♀♀ from Kampala, Uganda, in flowers of *Tephrosia*, ii.x.1921 (*H. Hargreaves*).

***Physothrips ventralis*, Hood.**

I am convinced by comparing Hood's description with that of *marshalli*, Bagnall, that the latter (May 1918) is a synonym of *ventralis*, Hood (April 1918). Third antennal joint quite yellow in some specimens, sometimes lightly shaded with

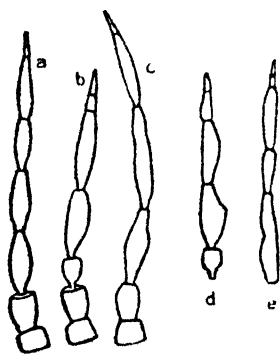


Fig. 4. *Physothrips ventralis*, Hood, antennae: a, normal; b-e, abnormal ("Ceratothripid" types); a-d, ♀♀; e, ♂; d, e, without joints 1 and 2.

brownish mesad, rarely brownish grey, whitish hyaline at base and at apex. The width of this segment, given by Hood as 53μ , is without doubt a misprint, as I have ascertained by comparing the specimens before me with a paratype of *ventralis*, which I owe to the kindness of Mr. Hood. Some of the antennae before me anomalous, probably regenerated (fig. 4). Number of bristles close before the middle of chief

vein usually 5, sometimes 4 or 6, in one of the fore wings before me 9 (whilst 6 on the other fore wing of the same specimen). Distal bristles 2, in one only of the fore wings before me 3 (whilst the other of the same specimen wanting).

Several specimens from Uganda, on flowers (*H. Hargreaves*), viz.: Kampala, 15.i.1921, on kasekekambajwe, 9.ii.1923, on kingiramuti, 6.i.1921, on *Ipomoea batatas*; Mpumumpu, 13.xii.1920, on plantain, with *Thrips kikuyuensis*; Luzira, 14.i.1921.

***Physothrips neavei*, sp. n.**

♀. Yellow, pterothorax slightly darker, orange-yellow; distal abdominal segments somewhat shaded with grey. All legs very pale whitish yellow. First antennal joint pale yellow; second slightly darker, somewhat infumate along both margins; third pale yellowish, very slightly tinged with greyish near the insertion of sense-cones; fourth whitish yellow in basal half, greyish brownish distad; following joints dark grey brown, extreme base of segment 5 pale.

Head wider than long. Occiput strongly rugulose transversely, genae slightly arched, very slightly diverging backwards, sculptured as in *Thrips kikuyuensis*. Eyes black, occupying about half the length of head. Ocelli approximate, arranged almost in a right-angled triangle, with bright red pigment cups; behind each posterior one a forwardly and inwardly directed bristle, as long as the diameter of one ocellus; laterad a similar one behind the inner hind angle of eye; on either side of the anterior ocellus also a similar, but shorter bristle; postoculars reduced to still shorter, inconspicuous bristle-hairs. Antennae (fig. 5) more than twice as long as head, with

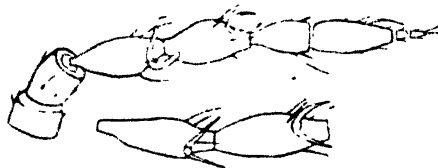


Fig. 5. *Physothrips neavei*, sp. n., antenna (above); *Thrips kikuyuensis*, antennal joints 3 and 4 (below).

thick joints; 1st and 2nd about cylindrical, following ones clavate; 4th widest in the middle; 5th transversely truncate at apex; 6th fusiform; style short and thick, about one-fourth the length of 6th joint; bristles on all joints moderately long and strong, sense-cones short and weak. Mouth-cone hardly reaching base of prosternum; palpi somewhat shorter and thicker than in *P. hargreavesi*.

Pronotum with short bristle-hairs on the whole surface; at either anterior angle a similar one, not longer but stronger than the others, forwardly directed. At each posterior angle two long and very strong bristles, about half as long as pronotum, the outer one hardly shorter than the inner. Front femora conspicuously thickened; front tibiae and tarsi without any tooth. Pterothorax a little longer than wide near the fore angles, with slightly rounded sides, a very little constricted at the hind margin of mesothorax. Sutures of meso- and metasternum practically as in *P. hargreavesi*, but the metasternal rhomb absent.

Wings reaching the last or penultimate abdominal segment, slightly tinged with greyish yellow on whole surface, except a hyaline, quite clear spot near base. Bristles of fore wings: costa 22-24; upper vein basad 4+3, distad 1+2; lower vein 12-14; scale as in *hargreavesi*.

Abdomen as wide as pterothorax, more than twice as long as wide. All bristles pointed, very short, except those on 9th and 10th segments, which are about as long as the segments themselves; apical segment conical, blunt at apex.

Measurements (in millimetres).—♀. Total length of antennae 0.23; first joint 0.02 long, 0.025 wide; second joint 0.03 long, 0.023 wide; third joint 0.043 long, 0.02 wide; fourth joint 0.043 long, 0.02 wide; fifth joint 0.035 long, 0.017 wide; sixth joint 0.048 long, 0.017 wide; seventh joint 0.005 long, 0.006 wide; eighth joint 0.006 long, 0.004 wide. Head 0.10 long, 0.14 wide. Prothorax 0.10 long, 0.17 wide (across fore coxae). Front femora 0.11 long, 0.06 wide; front tibiae (incl. tarsi) 0.16 long, 0.04 wide. Pterothorax 0.24 long, 0.22 wide. Middle femora 0.09 long, 0.04 wide; middle tibiae (incl. tarsi) 0.15 long, 0.04 wide. Hind femora 0.13 long, 0.05 wide; hind tibiae (incl. tarsi) 0.20 long, 0.04 wide. Length of wings 0.65 (without fringe). Abdomen 0.52 long, 0.22 wide. Total length 0.9–1.0.

I have named this new species in honour of Dr. S. A. Neave, Assistant Director of the Imperial Bureau of Entomology.

Seems to come nearest, amongst the hitherto known species, to the Spanish *P. navasi*, from which it differs, however, by the longer posterolateral bristles of the prothorax and by the number of bristles on the fore wings. In the structure of the head and some other characters, it recalls *Thrips kikuyuensis*, so that one could consider it as a variety with two-jointed style (as such are known already in some species of *Thrips*), if it were not too different in some other characters, especially in the shape of the antennal joints (fig. 5), which are (especially 3 and 4) much longer and more slender in *kikuyuensis*.

One ♀ from Kampala, Uganda, on flower of *Ipomoea hildebrandti*, 26.xii.1920 (*H. Hargreaves*).

***Thrips kikuyuensis*, Trybom.**

This species is very well characterized by the structure of the cheeks. The specimens before me agree with Trybom's description, but they have, besides the bristles described by Trybom, also between each posterior ocellus and eye a well-developed seta, which was apparently overlooked by Trybom, as he described the posterior ocelli as touching the eyes. These bristles, as well as those near the anterior ocellus, are nearly as long as the postocular ones, whilst the others behind eyes are much shorter. Fifth and sixth antennal joints not paler basad in the specimens before me. Fore wings dark, with a small hyaline spot near base (as described by Trybom), which becomes larger in some specimens, and sometimes even the whole basal part (including the scale) may be hyaline.

Several specimens from Uganda, on flowers (*H. Hargreaves*) viz.: Kampala, 6.i.1921; 9.ii.1923, on kingiramuti, with *Frankliniella dampfi*; 1.i.1921, on matovu; 6.i.1921, on mango (♂ flower); 6.i.1921, on *Ipomoea batatas*; Mpumumpu, on plantain, 13.xii.1920; Rubaja, 19.i.1921.

One ♀, with numerous *Physothrips sjöstedti*, from blossoms of *Dolichos lablab*, Morogoro, iv.1922 (*A. H. Ritchie*).

***Thrips acaciae*, Trybom.**

Three somewhat damaged ♀♀ from Babendi, Uganda, on *Caesalpinia* flower, 10.i.1923 (*H. Hargreaves*), with several *Physothrips sjöstedti*.

***Plesiothrips perplexus* (Beach).**

Five ♀♀, at base of sugar-cane leaves, Lautoka, Fiji, 6.ix.1920 (*W. Greenwood*).

The species was known hitherto only from the United States. I have compared the Fiji specimens with some from Illinois, which I received some years ago from Mr. Hood. The species somewhat recalls *Limothrips* by the shape of the head and by the weakness of the prothoracic and fore wing bristles.

TUBULIFERA.

Hoplandrothrips marshalli, sp. n.

♂, ♀. Dark brown, with some red hypodermal pigment. Front femora and tube slightly paler at apex. Front tibiae brownish yellow, darkened along both margins, especially in the middle part. Middle and hind tibiae dark. All tarsi yellow, with a blackish spot. First and second antennal joints as dark as the body, 2nd yellowish brown at extreme apex; joints 3 to 6 bright yellow, with the 3rd and 4th a little darker; 7th and 8th joints grey brown, 7th yellowish at base.

Head one and one-third times as long as broad; cheeks somewhat protruding behind the eyes, then straight and parallel, slightly constricted at base, finally granulated along the whole length and set with about 3 short, stout bristle-spines. Eyes occupying about one-third of the length of head, not protruding. Ocelli with large red pigment-cups, approximate, the posterior ones slightly more distant from each other than from the anterior one. Postocular bristles about as long as the eyes or a little longer, stiff and straight, slightly knobbed at apex.

Antennae (fig. 6, a) about as long as head and prothorax together, joints 3 to 6 broadly clavate, 7 and 8 together fusiform; all bristles comparatively long, curved

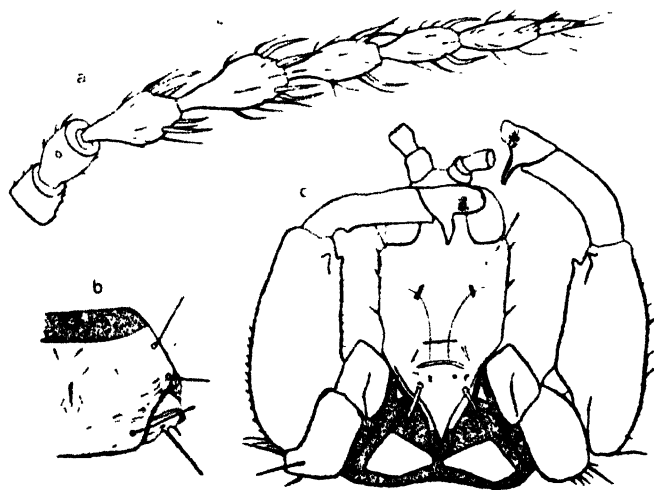


Fig. 6. *Hoplandrothrips marshalli*, sp. n.: a, antenna, ♀; b, right half of prothorax, dorsal view, ♀; c, head and prothorax, ventral view, ♂.

and very strong. Sense-area of 2nd joint placed close beyond the middle; sense-cones thick, hyaline, moderately short, bluntly pointed at apex; formula: iii, 1-2; iv, 2-2; v, 1-1; vi, 1-1; vii with one on dorsum near apex.

Mouth-cone (fig. 6, c) pointed, covering about two-thirds of prosternal length; palpi moderately long, labial ones about half as long as the maxillary ones.

Prothorax shorter than the head, widened backwards, across fore coxae twice as wide as long, in ♀ somewhat smaller than in ♂. Disc with a few very short hairs (fig. 6, b), a pair of which replace the quite absent anteromarginal bristles; all other bristles present, dark, very stout, blunt ("open") at apex, but not distinctly dilated; anterolateral bristles about as long as the postoculars, posterolateral and postero-

marginal ones a little longer, mediolaterals about half as long. For shape and arrangement of prosternal plates see fig. 6, *c*; space between them densely dotted.

Front coxae large; coxal bristle very stout, about as long as the anteromarginals; behind it 4 or 5 short, dark, very thick bristle-spines. Front femora moderately large and unarmed in ♀; greatly enlarged and swollen in ♂ with 2 teeth inside before apex (fig. 6, *c*). Front tibiae thick, curved in basal part, in ♂ with a short, acute tooth inside near base; apex before tarsus acutely produced. Front tarsus with a very large tooth in ♂, which is shorter and much more slender in ♀.

Pterothorax somewhat wider than long, with slightly arched, backwardly converging sides. Dorsal plate of mesonotum with transverse, that of metanotum with longitudinally arranged reticulation. Wings reaching beyond the base of 6th abdominal segment, very slightly constricted near the middle, brownish infumate, fore pair rather uniformly, hind pair especially along median vein; 2 sub-basal bristles, situated close behind sub-basal vein, long and strong, first longer than second; 11 to 14 interlocated ciliae.

Abdomen about as wide as pterothorax, three times as long as wide. Near either hind angle of all segments 3 stout, pointed bristles, increasing in length from basal to distal segments, on 6th about as long as the segment itself, on 9 only a little shorter than the tube. Wing-retaining spines well developed on segments 2 to 7, fore pair about two-thirds the length of hind pair; the latter on segment 5 about as long as the distance of their tips, gradually decreasing in length on the basal and distal segments; on segments 2 and 7 scarcely half as long as the distance of their tips. Tube short and stout, about two-thirds the length of head; the longer terminal bristles hair-like in distal part, somewhat shorter than the tube. The shorter terminal bristles hair-like throughout, outwardly curved, not half as long as the longer ones.

Measurements (in millimetres).—♂, ♀. Total length of antennae 0.55; first joint 0.05 long, 0.05 wide; second joint 0.055 long, 0.04 wide; third joint 0.09 long, 0.045 wide; fourth joint 0.10 long, 0.042 wide; fifth joint 0.088 long, 0.032 wide; sixth joint 0.07 long, 0.03 wide; seventh joint 0.06 long, 0.025 wide; eighth joint 0.04 long, 0.01 wide. Head 0.32 long, 0.22 wide. Prothorax, ♂ 0.24, ♀ 0.22 long, ♂ 0.52, ♀ 0.45 wide (across fore coxae). Front femora ♂ 0.38, ♀ 0.28 long, ♂ 0.17, ♀ 0.14 wide; front tibiae (including tarsi), 0.30 long, 0.06 wide. Pterothorax 0.45 long, 0.50 wide. Middle femora 0.21 long, 0.075 wide; middle tibiae (including tarsi) 0.30 long, 0.06 wide. Hind femora 0.32 long, 0.08 wide; hind tibiae (including tarsi) 0.40 long, 0.06 wide. Length of wings 1.1 (without fringe). Abdomen (including tube) 1.5 long, 0.5 wide; length of tube 0.21, width at base 0.09, width at apex 0.04. Total length 2.1–2.5.

I have the pleasure of naming this interesting new species after Dr. Guy A. K. Marshall, Director of the Imperial Bureau of Entomology, from whom I received this important Thysanopterous material for determination.

Quite different from all hitherto known species by the characters given above.

One ♂ (being the type), three ♀♀, from Najunga, Uganda, on coffee leaf, 24. v. 1921 (*H. Hargreaves*).

***Liothrips urichi*, Karny.**

Trinidad, 1922, on *Clidemia hirta* (*F. W. Urich*).

Larva (except head) bright red. Head, antennae, legs and two very large scutiform spots on prothorax dark brown; 9th abdominal segment and tube blackish. Bristles of all abdominal segments long, stout, curved, brownish.

Key to the African and Mediterranean Species of Liothrips.

1. Antennae partly yellow 2.
 Antennae black, the third joint being scarcely lighter in colour than the succeeding. Fore wings with 40 or more duplicated fringe hairs. Tube longer than the head. Length of body more than 3 mm. Subgen. *Ethiorthrips*, nov. (comprising *thomassetti*, *nigricornis*, and *intrepidus*, which may be distinguished from one another by Bagnall's key, Ann. Mag. Nat. Hist., (9) vii, p. 289, 1921).
2. All tibiae dark 3.
 Tibiae yellow, at least partly 12.
3. Head less than one-third longer than broad. Front tarsi with a distinct tooth. 4.
 Head more than one-third longer than broad 5.
4. Antennae one and a half times as long as head; 1st and 2nd joints brown, 3rd to 6th yellow, 7th yellowish, brownish distally, 8th light brown. Front tarsal tooth stout. Tube only a little shorter than head ... *tarsidens*, Trybom.
 Antennae nearly twice as long as head; 1st and 2nd joints brown, 3rd yellow, brownish distally, all others pale brown, 4th and 5th yellowish basad. Front tarsal tooth smaller, acutely pointed. Length of tube scarcely four-fifths the length of head *trybomi*, Karny.
5. Head less than $1\frac{1}{2}$ times as long as broad 6.
 Head $1\frac{1}{2}$ times or more as long as broad 9.
6. Tube less than half as long as head *micrurus*, Bagn.
 Tube more than half as long as head 7.
7. Postocular bristles inserted close behind the eyes, well developed, about three-quarters the length of eyes, slightly dilated at apex. Antennal joints, 1, 2, 7, 8 dark, the others yellow. Twelve doubled ciliae on fore wings
postocularis, sp. n.
 Postocular bristles shorter 8.
8. Postocular bristles knobbed, very short, not half as long as an eye, situated exceptionally far back, nearly halfway between hind margins of eyes and the neck; antennae with basal joint and basal half of second concolorous with head, joints 3 to 6 lemon-yellow, 7 yellow with apex slightly shaded with light brown, and 8 wholly of a light grey-brown; 15 to 18 duplicated ciliae
kingi, Bagn.
 Postocular bristles much reduced, hardly visible; antennal joints 1, 2, 7, 8 dark, the others yellow, 4th to 6th shaded with brownish in distal part; 7 to 12 doubled fringe hairs *dampfii*, Karny.
9. Head $1\frac{1}{2}$ times as long as broad. Antennae nearly one and a half times as long as head. Front tarsus unarmed* *major*, Buffa.
 Head more than $1\frac{1}{2}$ times as long as broad 10.
10. Antennal joints 1, 2, 7 and 8 dark. Length of tube about 0.6 the length of head 11.
 Antennae, except the basal joint, yellow. Tube about one-half the length of head *linearis* (Bagn.)
11. Basal antennal joint brown, 2 shaded to yellow apically, 3 clear yellowish white, 4 to 6 yellow, with 5 lightly and 6 more strongly shaded with brown apically, 7 brown, and 8 yellowish brown, lighter than 7 *reuteri* (Bagn.)
 First antennal joint very dark brown, 2 dark brown, except at apex, 8, 7, and distal half of 6 brown, the remainder pale yellow *africanus*, Vuill.

* These characters are taken from Buffa's figure.

12. Front tibiae yellow, greyish brown basally, and all tarsi yellow; hind and intermediate tibiae yellow distally *brevicollis* (Bagn.)*
 All tibiae yellow throughout *pragensis*, Uzel.†

***Liothrips postocularis*, sp. n.**

General colour black, all tarsi brown. First and second antennal joints brownish black; joints 3 to 6 yellow, uniformly coloured, but each joint a little darker than the preceding one; 3 pale yellow, 6 brownish yellow; joints 7 and 8 grey brown, 7 somewhat paler in basal third.

Head one and three-fifths times as long as wide. Eyes not protruding, occupying somewhat less than one-third of the length of head. Cheeks straight and parallel throughout, very finely granulated and set with some very short, weak bristle-hairs, which are visible under high magnifications only. Postocular bristles inserted close behind the eyes, blunt at apex, their length about three-fourths of the length of an eye. Vertex produced into a very short, blunt hump, bearing the forwardly-directed anterior ocellus.

Antennae (fig. 7) inserted close to the fore margin of eyes, one and a-half times as long as head, first and second joints cylindrical, first broader, second narrower than long, and constricted basad; following joints clavate; 7th fusiform, constricted basad, transversely truncate at apex; 8th conical. All bristles short and weak, even the pre-apicals shorter than usual. Longitudinal apical row of bristles reaching from the middle of 7th joint to apex of 8th. Sense-area of 2nd segment placed distad from the middle; all sense-cones hyaline, arcuate, pointed at apex; the outer

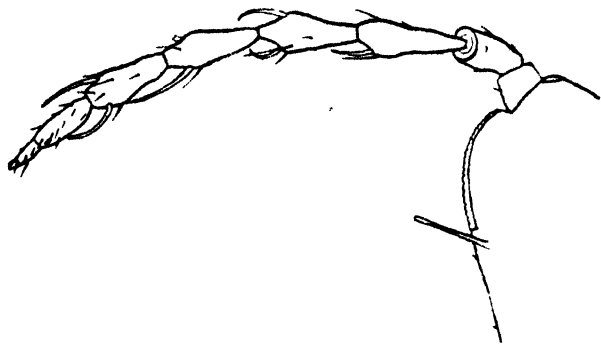


Fig. 7. *Liothrips postocularis*, sp. n., antenna.

(posterior) one of joint 3 short, the inner (anterior) one absent, perhaps broken off in the unique antenna before me; outer sense-cone of segment 4 even shorter than that of 3, inner one longer; outer sense-cone of joint 5 very long, reaching the broadest part of joint 6, inner one broken off near base; sense-cones of segment 6 also long, but shorter than the outer one of the preceding segment, inner one slightly longer than the outer one; median sense-cone of segment 7 not visible, but its insertion-area distinct.

Mouth-cone sharply pointed, reaching the hind margin of prothorax. Maxillary palpi very long and slender; basal joint about as long as wide, 2nd joint more than 6 times as long. Labial palpi much shorter, exceeding the apex of mouth-cone.

* Described as *Cryptothrips*, but very probably belonging to *Liothrips* (mouth-cone pointed, reaching across prosternum!).

† Described as a variety of *setinodis*, Reuter, but without doubt a separate species.

Prothorax five-eighths the length of head, widened backwards, across fore coxae not twice as wide as long; all bristles shaped as the postoculars, viz., blunt and very slightly dilated at apex; anterolaterals slightly shorter than postoculars, posterolaterals about twice as long as the anterolaterals; coxal bristle stouter, but not longer than the anterolateral one. Front legs moderately long, femora not thickened; tarsus unarmed. Pterothorax as long as wide; sides arched. Sutures of meso- and metasternum practically as in *urichi*, but on either side of the mesosternal triangle there is apposed another triangular chitinization, which is produced at apex into a short line directed against the fore angles of mesothorax. Wings reaching about the 7th abdominal segment, hyaline, equally wide throughout the whole length; sub-basal bristles stout, equidistant; 12 duplicated fringe-hairs.

Abdomen almost as wide as pterothorax; all bristles stout, bluntly pointed at apex, those on distal segments very long, on 9th as long as the tube; wing-retaining spines distinctly S-curved, stout and long, on middle segments as long as the distance of their tips. Tube short and stout, five-eighths the length of head, at base slightly less than half as wide as long, at apex half as wide as at base; sides straight, converging distad. Short terminal bristles somewhat less than half as long as the tube; long ones broken off.

Measurements (in millimetres).—Total length of antennae 0.5; first joint 0.03 long, 0.04 wide; second joint 0.05 long, 0.03 wide; third joint 0.09 long, 0.03 wide; fourth joint 0.09 long, 0.037 wide; fifth joint 0.08 long, 0.03 wide; sixth joint 0.065 long, 0.03 wide; seventh joint 0.055 long, 0.025 wide; eighth joint 0.035 long, 0.01 wide. Head 0.32 long, 0.20 wide. Prothorax 0.20 long, 0.35 wide (across fore coxae). Front femora 0.27 long, 0.11 wide; front tibiae (including tarsi) 0.30 long, 0.05 wide. Pterothorax 0.45 long, 0.45 wide. Hind femora 0.32 long, 0.06 wide; hind tibiae (including tarsi) 0.40 long, 0.05 wide. Length of wings 1.05 (without fringe). Abdomen (including tube) 1.45 long, 0.41 wide; length of tube 0.20, width at base 0.09, width at apex 0.045. Total length 2.4–2.5.

The differences from the hitherto known species may be seen from the key above.

One specimen, with 2 *Gynaikothrips uzeli hirsutus*, from Kampala, Uganda, in leaves of *Ficus* sp., causing curling of margin underneath, 10. ii. 1923 (*H. Hargreaves*).

Haplothrips bagnalli, Trybom.

Five carded specimens from Natal, Weenen, 2,840 ft., in thorn country, xi. 1923 (*H. P. Thomasset*).

Haplothrips cahirensis, Trybom.

This species was described by Trybom in 1911 from 2 ♀♀ only. It seems to have not been recorded since. Now, from the numerous specimens before me, I can add some characters to Trybom's description and note the differences from the other allied species described in the meantime.

General colour of freshly emerged specimens yellowish or reddish brown, with rich crimson pigment in the whole body; later on it becomes dark brown and the pigment is then less visible, often between the abdominal segments only, although it seems to be present in all specimens, but covered by the dark colour of the chitinous cuticula. Sense-area of 2nd antennal joint situated beyond the middle. Arrangement of sense-cones and bristles of joints 3 to 6, see fig. 8d. Third joint distinctly asymmetrical, much more convex at outer margin, with a sense-cone on either side, twice as long as broad; by this character the species may be distinguished easily from the South African *schultzei*, Priesner, in which the 3rd joint is one and a-half times only as long as broad; 4th joint about equal in length and width to the 3rd, or somewhat

larger, with 2 sense-cones outside, 1 inside; in one of the specimens before me joints 3 and 4 of one antenna are fused (fig. 8, *h*), whilst the other antenna is quite normal; 6th joint shaded with grey brown at least in distal half, often throughout, sometimes even as dark as the apical joints; in such dark-coloured specimens even the 5th joint may be somewhat darkened distally. In one of the specimens before me joints 6 and 7 of one antenna are fused, thus forming a large fusiform segment, in comparison with which the apical joint is very small, rather style-like (fig. 8, *g*); the other antenna of this specimen is quite normal. Head distinctly longer than broad and thus differing from both Seychellean species, *mahensis*, Bagnall, and *silhouettensis*, Bagnall, which are both characterised by their short head, not or scarcely longer than broad. Postocular bristles and all prothoracic ones slightly infundibuliformly dilated at the end (fig. 8, *a*). Postoculars about as long as the posterolaterals, but more slender,

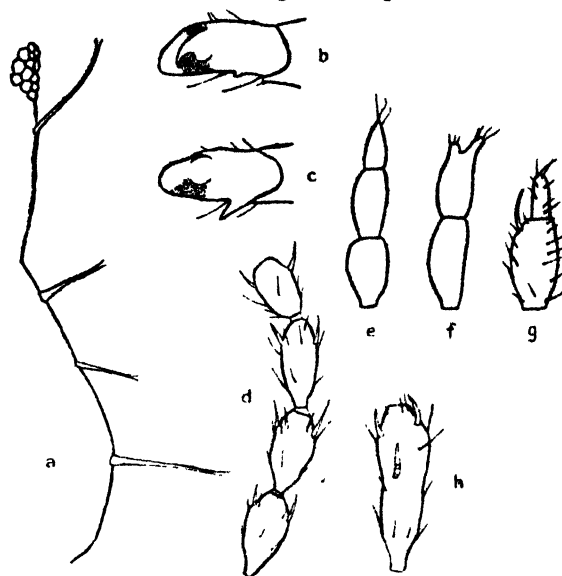


Fig. 8. *Haplothrips cahirensis*, Tryb.: *a*, lateral view of occiput and pronotum, showing marginal bristles; *b*, fore tarsus, ♀; *c*, fore tarsus, ♂; *d-h*, antennal joints; *d*, 3-6, normal; *e*, 6-8, normal; *f*, 6 and 7+8 (fused); *g*, 6+7 (fused) and 8; *h*, 3+4 (fused).

less dark and slightly curved. Prothoracic bristles all stout and stiff, dark brown; anterolaterals slightly more, mediolaterals slightly less than half as long as the posterolaterals, whilst in Trybom's specimens the anterolaterals were shorter than the mediolaterals. Prothorax much longer than in *brevicollis*, Bagnall (compare Trybom's figure with the measurements given by Bagnall for *brevicollis*). The front tarsi were described by Trybom as unarmed, because he had ♀ specimens only before him. In the ♂ they are armed with a distinct tooth (fig. 8, *c*), and even in the ♀ a very small tooth is often visible by strong magnification (fig. 8, *b*). Wings clear, hyaline, except the extreme base, which is dark brown. By this character the species may be distinguished from *karnyi*, Bagnall, which seems to be closely related to *cahirensis*, but has the wings with a smoky tinge. Bristles at base of fore wings stout and stiff, dark, shaped like the prothoracic ones. In distal part of hind margin 4 to 9 (usually 7 to 9) doubled fringe hairs (9 to 10 according to Trybom). Lateral bristles of abdominal segments 1-5 long and stout, stiff, dark, slightly dilated apically like the prothoracic ones. Bristles of all the following segments even longer, but almost hyaline, hair-like in distal part, sharply pointed at apex. Those on segments 7-9 only a little shorter than the tube (as in *karnyi*). Wing-retaining spines strong and dark, distinctly S-curved.

Several specimens of both sexes from Kampala, Uganda, on flower of matovu, 1. i. 1921; 1 ♀ on ♂ flower of mango, 6. i. 1921; 1 ♂ on flower of bugogma 6. i. 1921, having one antenna quite normal, whilst on the other the sixth joint is enlarged, the seventh bifid apically, eighth absent (quite united with 7) (fig. 8, f).

Haplothrips cahirensis var. **coloratus**, Trybom.

When I published the Sudanese Thysanoptera of Ebner's collection (1922), I considered *coloratus* as a distinct species, differing from *cahirensis* by the darker body, the pale 6th antennal joint and the less numerous doubled ciliae. Now, from the large material of *cahirensis* before me, I see that this point of view cannot stand, and Trybom was right in describing *coloratus* as a variety of *cahirensis*. As we now know in *cahirensis* all stages of coloration from light to dark brown, the colour of the body makes no difference, especially as also in *coloratus* under the dark chitinous cuticula there is present a rich crimson pigment quite as in *cahirensis*. As to the number of doubled fringe-hairs, it is so variable in the typical *cahirensis* that it may be even less than hitherto known from *coloratus*. Thus, the only difference between them remains the pale colour of the sixth antennal joint; but this is also a variable character only, because we find in *cahirensis* specimens with the 6th antennal joint darkened only distad and others having it grey-brown throughout.

One specimen (probably ♀) from Kampala, Uganda, on flower of matovu, 1. i. 1921, with numerous typical specimens of *cahirensis* (*H. Hargreaves*).

Haplothrips soror, Schmutz.

On flowers of *Cyperus*, Lautoka, Fiji, 11. viii. 1920 (*W. Greenwood*); on orchid flower, same locality and collector, 20. viii. 1920.

Hitherto known from Ceylon and Indo-China. The short, thick antennal joints are very characteristic.

Larvae pale yellowish; red hypodermal pigmentation: head, prothorax, front femora, abdominal segments 1, 2, 7 to 10; dark chitination: head, prothorax, pterothorax (slightly), antennae, legs, abdominal segments 8 to 10.

Oedemothrips ceylonicus, sp. n.

Abdomen black, thorax blackish brown, head castaneo-fuscous. Legs of the same colour as the head, except all tarsi, front tibiae and distal part of front femora, which are paler, yellow brown; fore tibiae darkened along both margins. Antennae: 1st joint pale, brownish yellow, 2nd slightly darker, 3rd yellowish brown, 4th greyish brown, 5th darker brown, 6th to 8th uniformly blackish brown.

Head (fig. 9) slightly wider than long, broadest near the hind margin of eyes; cheeks slightly arched, conspicuously converging backwards. Eyes small, black, occupying about one-fourth of the length of head. Postocular bristles stout, pointed, about as long as the eye. Ocelli small, arranged in an obtusangulate triangle, with red pigment, the posterior ones touching inner margin of eyes close before its hind angle; anterior ocellus directed forwards. Postocellar bristles very short and weak, shorter than the ocellus. Vertex not produced.

Antennae inserted close to the fore margin of eyes, not quite twice as long as head 1st joint short, with margins converging distally; 2nd joint constricted at base with rather parallel margins distally; following joints clavate; 5th obliquely truncate at apex; 6th joint transversely truncate at apex; 7th and 8th broadly united, together fusiform. Second joint with a few bristles before apex and one on inner margin near the base; sense-area placed beyond the middle; following joints with two transverse rows of bristles, which are relatively short on 3rd joint, gradually

increasing in length on the following joints; 3rd to 5th joints each with two sense-cones before apex, which are practically straight and about as long as the preapical bristles; 7th and 8th joints with bristles along the whole length.

Mouth-cone broadly rounded, reaching across prosternum not quite to its hind margin. Palpi short and thick.

Prothorax two-thirds the length of head, strongly widened backwards. All bristles bluntly pointed at apex; posterolaterals stout, nearly as long as the median length of prothorax; anteromarginals and anterolaterals about one-third the length of posterolaterals, anterolaterals very slightly shorter than the anteromarginals; posteromarginals about equal to the latter; mediolaterals much nearer to the antero- than to the posterolaterals, short and not very stout, somewhat curved. Front coxa with a very stout bristle, which is about half as long as the posterolateral prothoracic bristles; front femora enlarged; front tibiae short; fore tarsus armed with a moderately small tooth.

Pterothorax hardly wider than the prothorax across fore coxae, transversely rectangular, with protruding anterior angles. Mesosternal sutures arising from a small triangle, which is apposed to the hind cross-suture; from its front angle a longitudinal suture runs forwards; on each side is apposed another triangle, which is

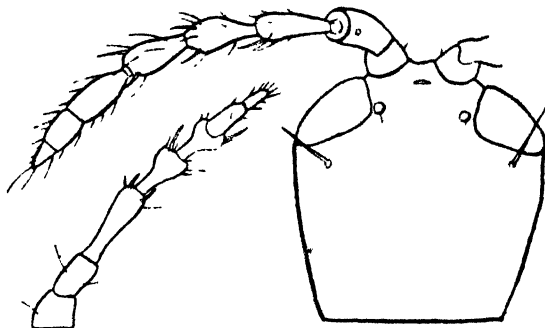


Fig. 9. *Oedemothrips ceylonicus*, sp. n.: head of imago, and antenna of larva.

produced laterally into an oblique cross-suture, ending far before the lateral margin; two oblique metasternal sutures, diverging backwards, reaching neither the hind coxae nor the front margin of metasternum. Middle and hind legs moderately long, stout, without a conspicuous bristle on outer margin.

Wings reaching about the base of 6th abdominal segment, of the same breadth throughout, uniformly smoky grey, but darker at extreme base. Fringe hairs not very dense, doubled at hind margin for about 7 hairs.

Abdomen ovate, much broader than pterothorax. Wing-retaining spines weak and rather short, on segment 7 slightly shorter than on 6. Lateral abdominal bristles very short and weak on basal segments; on segment 6 stout, somewhat shorter than the segment itself; on 7 to 9 very stout, brown, nearly as long as the following segment. Tube short and stout, hardly more than two-thirds the length of head, its lateral margins straight, strongly converging backwards. Apical bristles short and weak, alternating; the longer ones scarcely more than half as long as tube, curved inwards, the shorter ones curved outwards, about half as long as the others.

Measurements (in millimetres).—Total length of antennae 0.40; first joint 0.03 long, 0.04 wide; second joint 0.055 long, 0.03 wide; third joint 0.07 long, 0.03 wide; fourth joint 0.07 long, 0.033 wide; fifth joint 0.06 long, 0.032 wide; sixth joint 0.06 long, 0.03 wide; seventh joint 0.04 long, 0.025 wide; eighth joint 0.02 long, 0.015 wide. Head 0.22 long, 0.24 wide. Prothorax 0.14 long, 0.34 wide (across fore coxae). Front

femora 0.21 long, 0.10 wide; front tibiae (including tarsi) 0.24 long, 0.045 wide. Pterothorax 0.23 long, 0.35 wide. Middle femora 0.16 long, 0.06 wide; middle tibiae (including tarsi) 0.23 long, 0.04 wide. Hind femora 0.20 long, 0.05 wide; hind tibiae (including tarsi) 0.29 long, 0.06 wide. Length of wings 0.75 (without fringe). Abdomen (including tube) 1.3 long, 0.5 wide; length of tube 0.15, width at base 0.10, width at apex 0.05. Total length 1.9.

One imago, two larvae and one pupa, from Ceylon, Peradeniya, 1. x. 1924, on *Cassia multijuga* (F. P. Jepson).

Larva.—Yellowish, with rich red hypodermal pigment in the whole body; the following parts darkened with greyish: head, prothorax, legs (especially the tibiae); apical part of abdominal segment 8, and the whole of 9 and tube blackish grey. Antennae (fig. 9) dark grey, except basal joint, which is yellowish; 1st and 2nd joints about cylindrical, 2nd longer than 1st; joints 3 to 5 cylindrically constricted in basal half, strongly widened distally; 3rd about twice as long as 4th; 6th and 7th joints rather cylindrical, 6 longer and wider than 7. Abdominal bristles set on small blackish spots. Those on 9th segment longer than the tube; the latter with some weak, hair-like apical bristles, which are half as long as the tube, and with two stout and very long ones, which are at least as long as tube and 9th segment together.

Pupa.—Short and broad, brownish yellow, with slightly infuscated tube; rich red pigmentation in the whole body. Wing-cases about as long as the middle legs.

In spite of the presence of wings, this new species must be placed in *Oedemothrips*. It comes here nearest to the Japanese *brevicollis*, Bagnall, differing from it especially by the much weaker and shorter interocular (postocellar) bristles, by the shorter prothorax, presence of wings, and by the much shorter tube.

***Chelacothrips idolicaps*, sp. n.**

Black. Front tibiae and all tarsi yellow, the former darkened along both sides. First antennal joint as dark as the body, 2nd brown, paler especially towards the apex; all the following joints lemon yellow. Wings greyish brown, infumated on whole surface, somewhat darker along median line.

Head (fig. 10) more than twice as long as broad, before the eyes produced into a long conical process between the antennae, bearing the anterior ocellus, which is directed forwards. Posterior ocelli situated close to the inner margin of eyes near the front angle, conspicuously more distant from the anterior ocellus than from each other. Eyes occupying about one-third of the length of head (excluding the anterior process). Cheeks very slightly arched, smooth, with some short bristles.

Antennae (fig. 10) about as long as head; 1st joint cylindrical, outside one and a half times as long as broad, inside not quite half as long as broad. Second joint as long as broad, as broad as the first, strongly constricted basally, strongly inflated distally; 3rd to 6th joints broadly clavate; 7th and 8th together fusiform. Bristles practically as in *annamensis*. Sense-area of 2nd joint situated distally; sense-cones of joints 3 to 6 falcate, somewhat shorter than the joints themselves; on the 3rd inner one quite rudimentary; median sense-cone of 7th joint shorter than the others, exceeding the middle of 8th joint.

Mouth-cone broadly rounded, scarcely exceeding the middle of prosternum. Labrum almost a right-angled triangle, with slightly excavated lateral margins. Palpi practically as in *annamensis*.

Prothorax half as long as head, with short, stout setae. Front femora strongly incrassate; tibiae short and thick; tarsus with a sharp, stout, somewhat curved tooth. Pterothorax with slightly protruding front angles and sinuated lateral margins. Median portion of pterothorax, and 1st and 2nd abdominal segments with

longitudinally arranged reticulate sculpture. Meso- and metasternal sutures practically as in *annamensis*, but the latter not meeting each other. Middle and hind legs moderately long and very stout.

Wings (excluding fringe) reaching the 7th abdominal segment, equally wide throughout, not constricted in the middle. Hind margin of fore pair distally with 15-16 doubled fringe hairs.

Abdomen somewhat narrower than pterothorax. Lateral bristles on segment 2 short and not very strong; on the following segments brownish yellow, very stout, about half as long as the segments, on 9th longer than the segment itself. Wing-retaining spines strong, brown, but not very long, S-curved, conspicuously shorter than the distance between their tips. Tube long and slender, about one-fifth shorter than the head, slightly tapering distally; terminal bristles four, brown, long and stout, more than half as long as the tube itself; between them about 8 hair-like bristles, scarcely one-third as long as the long ones.

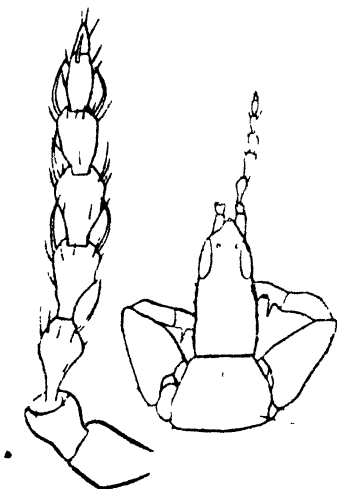


Fig. 10. *Chelaeothrips idoliceps*, sp. n.: head and prothorax (right), and antenna (left).

Measurements (in millimetres).—Total length of antenna 0.45; first joint 0.08 long outside, 0.02 long inside, 0.05 wide; second joint 0.05 long, 0.05 wide; third joint 0.075 long, 0.035 wide; fourth joint 0.073 long, 0.04 wide; fifth joint 0.07 long, 0.04 wide; sixth joint 0.06 long, 0.035 wide; seventh joint 0.055 long, 0.03 wide; eighth joint 0.027 long, 0.015 wide. Head 0.44 long, 0.20 wide. Prothorax 0.20 long, 0.37 wide (across fore coxae). Fore femora 0.28 long, 0.16 wide; fore tibiae (including tarsi) 0.24 long, 0.065 wide. Pterothorax 0.39 long, 0.42 wide. Middle femora 0.25 long, 0.10 wide; middle tibiae (including tarsi) 0.29 long, 0.06 wide. Hind femora 0.34 long, 0.10 wide; hind tibiae (including tarsi) 0.37 long, 0.06 wide. Length of wings 1.1 (without fringe). Abdomen (including tube) 1.55 long, 0.38 wide; length of tube 0.35, width at base 0.08, width at apex 0.045. Total length 2.5-3.0.

Described from 15 carded specimens, from Labasa, Fiji Islands, 21. x. 1922, feeding inside rolled-over edge of leaf of *Ficus* (*W. Greenwood*).

By the characters given above *idoliceps* differs widely from both the hitherto known species of the genus, *Chelaeothrips annamensis* and *exunguis*, and it should come in the IDOLOTHRIPIDAE if we have regard only to the situation of the ocelli. Nevertheless, all the other characters are so different from those of the latter family that it must be placed in the PHLOETHRIPIDAE. Amongst these there is no

other genus related to *idoliceps*, except *Chelacothrips*, with which it agrees in the general shape of the head, the relatively short and thick antennae, the strongly incrassate front femora and the strongly armed front tarsi. It must be placed, therefore, in this genus, unless it seems preferable to erect a new genus for this remarkable species.

***Gynaikothrips uzeli* (Zimmerman) *hirsutus*, subsp. n.**

Head as in *uzeli*; setae of cheeks more numerous and stouter (fig. 11). Antennae broken off in all the five specimens before me. Mouth-cone broadly rounded. Front femora somewhat thickened, set with short, stout bristles, especially along outer margin. Front tibiae black; all tarsi dark brown. Wings hyaline; hind margin of fore wing with 19 to 23 duplicated ciliae. Tube very slightly shorter than head, with nearly straight, distally converging margins. All other characters practically as in *uzeli*.

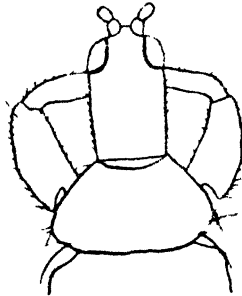


Fig. 11. *Gynaikothrips uzeli hirsutus*, subsp. n., head and prothorax.

Measurements (in millimetres).—Head 0.35 long, 0.24 wide. Prothorax 0.23 long, 0.48 wide (across fore coxae). Front femora 0.30 long, 0.13 wide; front tibiae (including tarsi) 0.24 long, 0.07 wide. Pterothorax 0.46 long, 0.52 wide. Middle femora 0.28 long, 0.08 wide; middle tibiae (including tarsi) 0.33 long, 0.06 wide. Hind femora \pm 0.35 long, 0.10 wide; hind tibiae (including tarsi) \pm 0.45 long, 0.06 wide. Length of wings 1.3 (without fringe). Abdomen (including tube) 1.8 long, 0.54 wide; length of tube 0.34, width at base 0.10, width at apex 0.05. Total length 2.6–3.0.

Differs from both *uzeli* and *scotti*, Bagnall, by the dark front tibiae and by the somewhat more numerous doubled fringe-hairs; from the latter, moreover, by the hyaline wings. It is not impossible that the antennae will show some further differences, and then it may perhaps become necessary to consider it as a different species. For the moment, as the antennae are not yet known, I think it more reasonable to place it provisionally as a subspecies of *uzeli*.

Five specimens from Kampala, Uganda (*H. Hargreaves*): 3 from an unknown food-plant, 20. x. 1921; 2 from leaves of *Ficus* sp., causing curling of margin underneath, 10. ii. 1923, together with *Liothrips postocularis*.

***Machatothrips braueri*, Karny.**

Of the few fully developed specimens in the collection before me, only 2 have the front femoral teeth of the same shape as in the hitherto known specimens of *braueri* (Treubia, ii, p. 64), whilst three others have all the teeth, including the distal ones, simple like those of *heveae*, differing from this latter species by the first (basal) tooth being larger, as in the typical *braueri*, being as large as or even larger than the second one. I name this variety var. ***haplodon***, nov. The remaining specimens

have no teeth at all (var. **buffai**, nov.), like the Malaysian *biuncinatus*, Buffa (1909). It is very probable that *braueri* will prove to be nothing else than the African form of *biuncinatus*.

Further, in the material before me there are five larvae and one pupa, all with rich hypodermal pigmentation throughout the whole body. In the larva the following parts are darkly chitinised: antennae, head, the greater part of pronotum, all the legs, some spots on abdominal segments at the bristle insertions, a cross band on segment 8, the whole of 9 and tube. The pupa has a strong front tarsal tooth, without front femoral teeth; wing-cases reaching about the 3rd abdominal segment.

One dried specimen (var. *buffai*) from Ibadan, Nigeria, 20. v. 1923, on cacao (*F. D. Golding*). One (var. *buffai*) from Belgian Congo, on cacao (*R. Mayné*). The others (including type specimens of both the new varieties) from Kampala, Uganda, 8. viii. 1921, feeding in galleries of a Scolytid beetle in bark of dead *Ficus ovata* (*H. Hargreaves*).

***Bactrothrips longiventris*, Karny.**

Belgian Congo, on cacao (*R. Mayné*), 4 ♂♂, 2 ♀♀, 1 pupa; the latter with rich hypodermal pigment throughout the whole body, the legs and the basal part of antennae; distal abdominal segments (fig. 12) with much smaller processes than in the fully developed ♂.

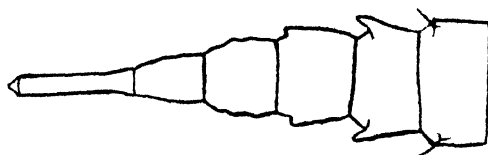


Fig. 12. *Bactrothrips longiventris*, Karny, abdominal segments 5-10 of ♂ pupa.

Krinothrips divergens, Bagnall, is very probably a synonym of this species.

THE FUMIGATION OF CITRUS TREES IN PALESTINE.

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(PLATES V-VIII.)

Citrus Cultivation in Palestine.¹

The cultivation of citrus trees in Palestine is by no means modern, for as far back as the tenth century A.D. the Arabs discovered the "bitter orange" in Northern India, and it was, in all probability, brought into this country shortly afterwards. Jacques de Vitry, who made a visit to Palestine in the 13th century, mentions several varieties of citrus.

The Arabic name for orange, "bortugan," indicates that this fruit was introduced into Palestine from Spain or Portugal. About the end of the 18th century cultivation was commenced on a fair scale at Jaffa, but warfare in 1773 and 1779 appears to have constituted a severe set-back, owing to widespread destruction of the groves.

In 1835 the Jaffa gardens are described by a reliable writer as the finest on the shores of the Mediterranean. To-day Jaffa oranges are famous, but the gardens from which they originate cannot, on the whole, be said to be models of good cultivation, methods of tree planting or pruning.

According to Dr. Weinberg² the areas under citrus cultivation in Palestine amount approximately to some 7,500 acres. By far the greatest portion of this acreage is under oranges; tangerines, mandarin oranges and lemons occupy but a small percentage of the area. Practically all the fruit that is grown for export emanates from the Jaffa district and the Arab villages, and German and Jewish colonies in its vicinity. A glance at the map (Plate viii) will indicate the position of the principal citrus-growing centres of Palestine. This concentration of fruit production about a port (Jaffa) is of considerable advantage from the point of view of transport costs and natural standardization of the product.

The average area of a Palestinian orange garden varies from 7 to 14 acres; the largest garden in Palestine is close on 200 acres in extent and is situated at Baharia, some little distance from Jaffa. The number of trees planted to the acre is roughly between 250-260, and the average seasonal yield is about 220 boxes to the acre (an average Palestinian box of oranges contains 144 oranges). The average height of the trees varies from 10 to 14 feet; they are often very irregular in shape owing to inordinately close planting.

The export of oranges from Jaffa has steadily increased since 1887 (when the first records became available), the only set-back experienced being during the war period (1914-1918), combined with a severe invasion of locusts in 1916. In the season 1887-1888, 100,515 boxes were exported; in 1913-1914, 910,548; in 1914-1915, 109,209; in 1923-1924, 1,584,081 boxes were exported at a value of 419,457 Egyptian pounds.* The principal countries to which the fruit was exported during this season were, in order of importance, the United Kingdom, Egypt, Rumania, Syria and France.

Since the war a slight increase in acreage has taken place, due to some extent to the enhanced prices obtained for the fruit abroad (the result of superior methods of grading and packing) and the ever increasing local demand—the result of Palestine's steadily growing population. A sure sign of the times is the existence of an active co-operative orange-growers' association.

* The value of the Egyptian pound is fixed at £1 0s. 6d.

The cultivation of Palestinian citrus fruits, with some exceptions, leaves much room for improvement. The supplying of irrigation water at somewhat irregular intervals during some six months of the year (roughly speaking from May to October), a vigorous turning over of the soil with a plough or more usually by hand with a heavy broad mattock performed sometime in April or May, the application of animal manure and the removal of the more conspicuous dead branches, constitute, in many cases, the sum total of the items under the headings of cultivation. In many gardens vegetables are grown in convenient spots beneath the trees.

The care and maintenance of many of these orchards is usually left solely to a resident caretaker, while the real owner but seldom visits his property and is only interested in the collection of profits with the barest minimum of expenditure on cultivation and upkeep.

Abnormally close planting of the trees is a regular feature in many Palestinian orange groves, and it is by no means uncommon for the upper branches of the trees to interlace to such an extent that the rays of the sun are shut out from the soil and foliage beneath. Such conditions are undoubtedly conducive to shade and coolness—so welcome during the hot summer months—but they by no means constitute good cultivation. In fact such features are apt to render the successful treatment of insect pests such as scale-insects an exceedingly difficult matter.

A fair percentage of gardens have been planted and are maintained according to up-to-date methods; larger yields of superior quality fruit are the inevitable result.

Scale-insects of Citrus in Palestine.

The following injurious COCCIDAE are found on citrus in Palestine :—

1. The Common Mealy Bug : *Pseudococcus citri*, Risso.
2. The Australian Fluted Scale : *Icerya purchasi*, Mask.
3. The Soft Scale : *Lecanium hesperidum*, Linn.
4. The Mussel Scale : *Lepidosaphes beckii*, Newman.
5. The Florida Wax Scale : *Ceroplastes floridensis*, Comst.
6. The Chaff Scale : *Parlatoria oleae*, Colvée.
7. The Black Scale* (local name) : *Chrysomphalus ficus*, Ashm.
8. The Red Scale : *Chrysomphalus aurantii*, Mask.

Of these species only three can be said to be of any great economic importance—they are the red scale, the black scale and mussel scale. Of these three the black scale is of by far the greatest importance, and it is towards the elimination of this pest that fumigation by means of hydrocyanic-acid gas has been instituted. Evidence strongly supports the theory that *Chrysomphalus ficus*, Ashm., was first introduced into Palestine from Syria some fifteen years ago, and since then it has spread through those northern districts of Palestine which adjoin Syrian territory.

A glance at the accompanying map will indicate the areas thus already infested. The penetration has been a sure and steady one, aided during the years of war by neglected cultivation and locust attacks, with consequent weakening of the trees and predisposition to infection. The famous Jaffa orange-growing districts are at present entirely free from this pest, but the threat of infestation is a serious one. Should these groves become infested, the valuable industry of orange exportation would, without doubt, be adversely affected, as the previously described lax cultivation

* The term "black scale" for *Chrysomphalus ficus*, Ashm., is entirely of Palestinian origin, and is used to distinguish this species from the red scale (*Chrysomphalus aurantii*, Mask.). It is used in this sense throughout this paper.

methods, close planting and consequent interlacing of branches, would render the manipulation of fumigation tents an extremely difficult procedure in the majority of gardens.

The opinion is sometimes expressed that the Jaffa orange is peculiarly resistant to attack by scale-insects, but the writer has seen the Jaffa type of orange growing in parts of Palestine other than the Jaffa district just as thickly incrustated by large colonies of the black scale as other varieties growing in close proximity. It has come under the observation of the writer, however, that during the summer months the trees in the Jaffa groves become coated with a white, calcareous dust, which is distributed by traffic on the roads in the neighbourhood; this may contribute to some extent to the general absence of scale-insects on the oranges grown in Jaffa. Somewhat similar effects have been observed in France in the case of grape vines, where the presence of a coating of road dust has resulted in the absence of disease, otherwise prevalent.

The black scale, when present in the Palestinian orange grove, flourishes to an extraordinary extent. It is no uncommon spectacle to observe the golden yellow colouration of a ripe fruit to be almost totally obscured by the adhering, scab-like incrustations formed by the innumerable, overlapping colonies of the pest (Plate vii). The leaves may be similarly covered, but the insects are seldom, if ever, seen on the twigs and branches. Eucalyptus trees, which are often used as wind-breaks, are liable to become heavily infested, and act as alternate hosts and re-infest the orchards after treatment by fumigation. Bananas and quite a large number of other plants are liable to infestation, but not in the same degree of severity.

The injury to infested trees is great: leaves drop off prematurely, the fruit becomes undersized and unsightly, and the whole tree bears each year a smaller crop of fruit. Oranges infested with black scale fetch a low price on the market; the only alternative being to expend money on labour in removing the scale by hand prior to marketing. During the spring and early summer months it is often hard to discover the presence of this Coccid in orange groves known to be heavily infested; this is due to the fact that the insects from the previous year's foliage—which dies off and drops from the trees on the coastlands during April—have not yet multiplied to any great extent on the fresh foliage.

From September to March the black scale is rampant. All species of citrus are equally liable to attack; but it is interesting to note that the bitter orange, used as stocks, is inclined to be resistant to this pest.

The red scale is found all over Palestine but seldom causes any wide-spread damage. It is found throughout the Jaffa area, but cannot be said to rank as a pest of any great economic importance there. Lemon trees appear to be peculiarly liable to pernicious attacks by the red scale.

The mussel scale was first recorded from one garden in the Jaffa District by Gough⁸ in 1921. Since that time it has spread to several adjoining groves and is gradually assuming an economic importance. It is proposed to treat the affected areas by means of fumigation during 1925.

Fumigation Methods and Results.

Fumigation of citrus trees in Palestine was inaugurated on a correct scientific basis by the writer early in 1923. As this work, from its inception, has been of a pioneer nature an account is given here of the modifications in and additions to the accepted methods found necessary in order to meet peculiar local conditions. It is hoped that such details may prove of some value to workers who may find themselves in the future faced with problems of a similar nature.

The canvas tents used for covering the trees during fumigation have been of the conventional octagonal shape measuring 40 feet across and marked by means of quick-drying black paint, locally compounded. This marking of the tents has been executed according to the method established by A. W. Morrill.⁴ At present only the one size has been utilised, as it has proved the most convenient for the Palestinian trees. Up to the present these tents have been manufactured by firms in Cairo, Egypt, who have had previous experience in such work for the Egyptian Ministry of Agriculture.

These tents have adequate gas-retaining properties and will stand the somewhat rough conditions of usage imposed by local conditions. Mildew-proofing compounds have not, up to the present, been found necessary. An experiment is at present in hand whereby these tents will be woven and constructed by convict labour at the sole cost of the cotton utilised.

The poles used for manipulating the tents are of the usual size and their use has been quickly appreciated and learnt by the local labourers. Tent-poles from old army stock have proved very satisfactory.

After trials of a large number of locally-made earthenware pots of varying shapes and sizes for gas generating purposes, preference has been given to a black earthenware kind manufactured at Gaza in Southern Palestine. In height they are 22 inches, with a diameter of 5½ inches at the mouth and 12 inches at the broadest portion. They have the advantage of being exceedingly cheap, not easily broken, portable and readily procurable. A good percentage will retain their acid-resisting properties throughout one season. Special metal covers have been designed for use with these jars. The supplies of sodium cyanide and acid have been procured from the United Kingdom; the only difficulty experienced has been in obtaining the cyanide packed in large tins and broken up to a size which will easily pass into the mouth of the generators. The waste and expense of labour employed in opening and emptying a number of small tins of cyanide and in breaking up the chemical to a suitable size is considerable.

The dosage schedule employed has been in invariable accordance with the No. 1 schedule (100 per cent.) as drawn up by the United States Department of Agriculture.⁵

Experience in fumigation work gained up to the present in Palestine indicates that it is only possible to carry out this operation during certain months of the year. During the winter months—which may, strictly speaking, be said to commence in November and end with February—the frequent occurrence of high winds and heavy rain hinders regular execution of the work to such an extent as to make it an impracticable proposition. During March and April the trees drop their last year's foliage, blossom and put forth their new foliage; fumigation, therefore, cannot be performed during this period without serious risk of severe damage to the tender foliage and the setting of the flowers. The months named for this critical period in the life of the trees varies, of course, according to the altitude above sea-level or the number of feet below sea-level. For instance, this interval commences several weeks earlier along the shores of Lake Tiberias (682 feet below sea-level) than at sea-level; at Nazareth (1,600 feet above sea-level) it will be several weeks later than at sea-level. The months named above apply to sea-level.

In the Haifa area, at sea-level, work has been successfully inaugurated towards the end of April and carried on till the end of July, when high nocturnal temperatures and general conditions of dryness deterred further operations. The work has been recommenced during September and carried on until the latter part of November. This Haifa area experiences abnormally high nocturnal temperatures owing to its preclusion from the cooling night winds by the Carmel Range of hills. In other coastal districts, exposed to such breezes, it should be possible to continue fumigation, without a break, from April to November. At higher altitudes a similar period would also be available.

About the shores of the Lake of Tiberias (682 feet below sea-level) operations have been conducted from late September till the commencement of December with excellent results.

The occurrence of sirocco winds, during the early and late summer months, with accompanying high nocturnal temperatures (up to 100° F. in the Haifa area) and conditions of extreme dryness have caused a cessation of fumigation work for several nights together.

Palestine citrus trees can successfully withstand fumigation with hydrocyanic acid gas at temperatures considerably higher than those considered safe in other parts of the world. This is possibly due to their natural and necessary powers of resistance to the protracted, hot, dry summer experienced in this country.

Fumigation operations have been directed entirely against the further spread of the black scale towards the large and valuable orange-growing districts of Jaffa. A glance at the map will indicate the areas at present infested with this scale-insect. Extended operations have been already carried out in the Haifa area, along the shores of the Sea of Galilee and in the neighbourhood of Akka. The elimination of the pest is proceeding, but the work is necessarily retarded owing to slow conditions of working imposed by the close planting of many gardens and the fact that heavily infested groves have to be treated two years in succession so as to obtain complete clearance of the scale. Some 25,000 trees have been fumigated and something like treble that number await treatment. Black scale should be under control within the next three years.

The peculiar close planting and irregular growth of the trees, as well as the rough, often sandy nature of the soil in many Palestinian citrus groves, have rendered necessary the institution of special methods of procedure in fumigation work. Unskilled labour has had to be utilised and trained almost in every instance. The following method of working in such groves has been devised to meet the above set of circumstances and has, under extended use, given good results.

The tents are first of all pulled over the trees in as straight a line as possible. In many groves it is often impossible, owing to the extremely close growth of the trees, to cover one tree at a time. Several adjacent trees are therefore covered by one tent, care being taken to leave as little unfilled space under the tent as possible (Plate v, figs. 1 and 2).

The operator in charge then takes the measurements of each tent, starting at one end of the row and working down it, taking each tent in succession. The measuring is performed according to accepted practice, making use of a tape measure and the scale marked on each tent. These measurements are recorded in a special book, and as each entry is made the operator in charge affixes to the tent a waterproof label bearing the number of that tent. With practice this operation is rapidly and easily performed by the operator in charge and two labourers who manipulate the measuring tape. The supply of chemicals, measures, weighing machines, etc., is placed in close proximity to the line of tents and is moved up regularly into an easily available position as the work progresses (Plate vi, fig. 1). As soon as the measuring of the trees is completed the operator in charge, after referring to the dosage table previously mentioned, calculates the amount of acid and cyanide for each tent according to his measurements and enters these amounts in his notebook.

The following procedure is adopted for generating the gas beneath the tree. One man proceeds to tree number 1 in the row and raises the edge of the tent in a manner so as to allow the convenient placing in position of the generating pots. The labourers, in turn, come up to the measuring table and each receives a metal shovel and generating pot; the shovel containing a quantity of cyanide, weighed according to dosage calculations, and the pot a similar measured quantity of sulphuric acid and water. Each labourer is given verbally the number of the tent for which his quantities

of acid and cyanide are intended and then proceeds to the scene of operations. The man who is lifting the tents checks the numbers on the labels, previously attached to the tents by the operator, with the numbers given to each labourer and sees to it that each tent thus receives its correct dose.

The operator is employed in measuring the quantities of cyanide on a self-recording scale with removable pan, from which the cyanide is transferred to the metal shovels, and also in calling out the quantities of acid and water to his assistant, who is responsible for the correct measuring of these quantities and for the transference of them to the generating pots. The operator is careful to see that each labourer carries the correct amount of chemicals for the tent to which he tells him to proceed.

The labourers put the pots in position beneath the tents, pour the cyanide from the shovel into the generating pot and at once return for further supplies. Thus a continuous procession of labourers between the measuring table and the tents is maintained. With practice a high standard of proficiency is reached, and the work is performed speedily and without hitch or delay.

Shifting the tents in badly planted and ill-kept gardens occupies almost double the time required when trees are planted regularly and kept properly pruned. Under bad conditions, working with six labourers, one operator and an assistant, thirty tents and an eight-hour shift, the number of trees covered will be 140-150.

Complete records of all trees fumigated are kept by means of the operator's notebook; notes on atmospherical conditions and any other events of fumigation interest are also made. The practice has been adopted of marking the trunk of each tree with whitewash as soon as the tent is withdrawn after fumigation.

By fumigating a heavily-infested garden during two successive seasons, 100 per cent. elimination of the black scale has been obtained. These results have been observed by examination of the trees 4-5 months after treatment and at the time when black scale, if present, will be at its maximum. Increased growth of foliage and superior yields of clean fruit have also been noted.

At the present stage of operations it would appear as though slightly better results are obtained by fumigating during the early summer months, *i.e.*, before thorough re-infestation has taken place from the previous year's foliage.

The fact that there is an ever-increasing number of requests for fumigation from growers themselves indicates some measure of appreciation on their part.

The recent institution in Palestine of a Plant Protection Ordinance has made the prosecution of the campaign against the black scale a somewhat easier matter. In accordance with similar Ordinances elsewhere, the Palestine Government is now empowered, where necessary, to compel a cultivator to control the spread of certain pests (of which the black scale is one) in the lands under his occupation, and it is proposed to carry on fumigation work under this Ordinance in future.

Experiments are now in hand on the use of calcium cyanide dust. If these prove successful, the pot method of fumigation with sulphuric acid and sodium cyanide may be superseded.

Perhaps it is not too much to hope that the successful institution of up-to-date methods of controlling the most pernicious insect pest of Palestine's valuable citrus orchards, and the interest aroused among local cultivators in such methods, may lead to a furthering of that interest in the direction of improved cultivation, and the evident lucrative possibilities of this crop may be taken fuller advantage of than they are at present.

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EXPLANATION OF PLATE V.

Fig. 1.—Fumigation tents (25) in position in an irregularly planted and badly kept orange grove in the Haifa area. Several trees are under one tent, owing to the impossibility of covering one tree at a time. Under such conditions it is impossible to place the tents in a straight line. Despite difficulties of working, 99 per cent. elimination of the scale was obtained.

Fig. 2.—Hauling a tent over a tree.



Fig. 1.



Fig. 2.

Citrus Fumigation in Palestine.

EXPLANATION OF PLATE VI.

Fig. 1.—Measuring out the quantities of cyanide and acid. In the centre is the operator-in-charge, who is calling out the measurements. On his right a foreman is supplying the requisite quantities of acid and water ; on his left is the cyanide weighing machine. On his extreme left are two labourers proceeding to the tents carrying the generators that contain the acid and water in their left hands and the metal shovel containing the cyanide in their right. Note supply of pots and shovels in the foreground.

Fig. 2.—Personnel consisting of Government Entomologist, Assistant, two foremen, and labourers.

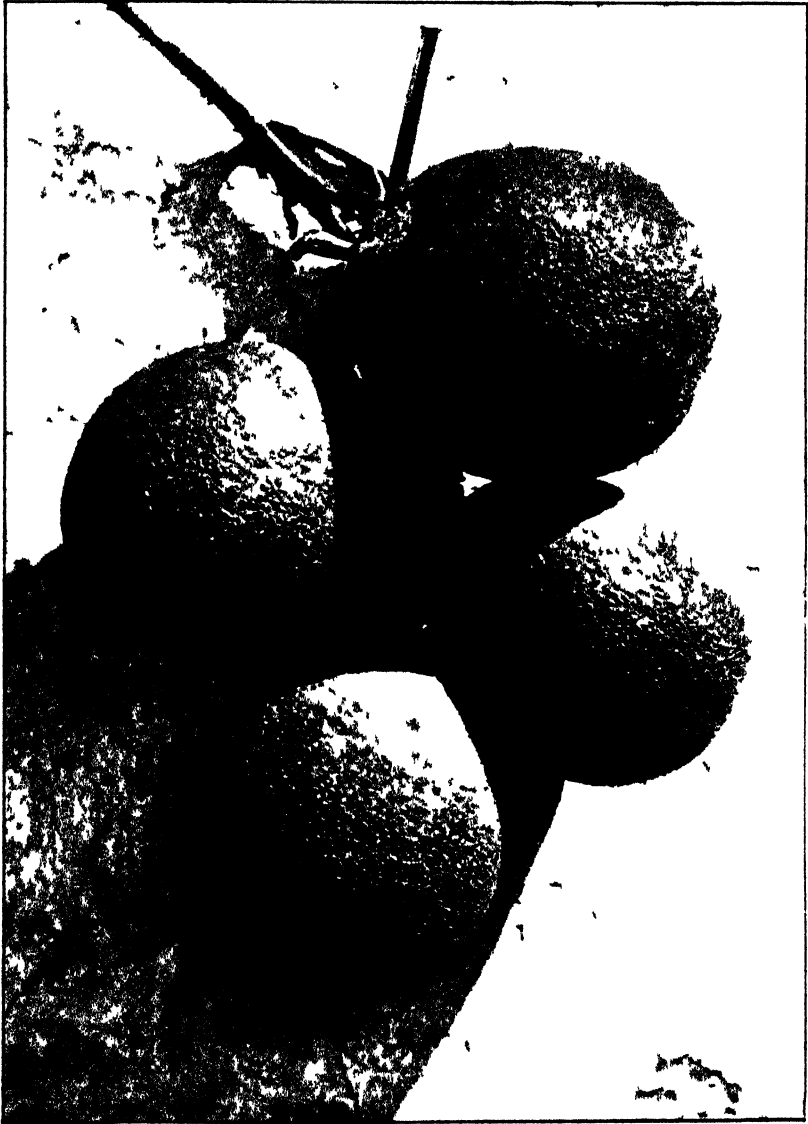


Fig. 1.

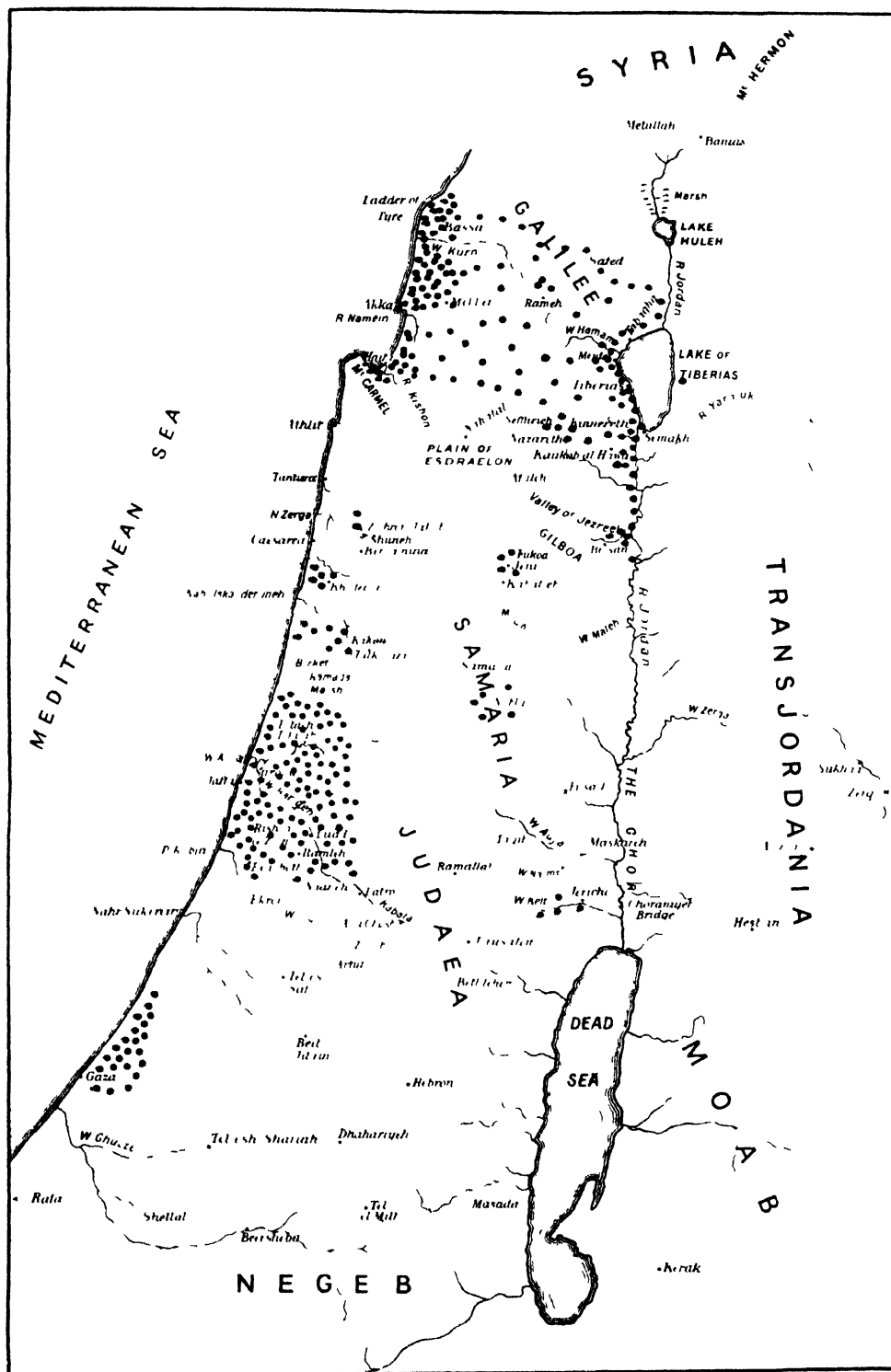


Fig. 2.

Citrus Fumigation in Palestine.



Oranges from Haifa District infested with Black Scale (*Chrysomphalus ficus* Ashm). The incrustations almost entirely obliterate the golden yellow colour of the fruit



MAP OF PALESTINE

RACE SUICIDE IN STEGOMYIA.

By P. A. BUXTON, M.R.C.S., L.R.C.P., D.T.M. & H.,

and

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(Expedition of the London School of Hygiene and Tropical Medicine to Samoa.)

If the destruction of the breeding-places of *Aedes argenteus* (*aegypti*, *fasciata*) is carried out too completely, it is known that some of the females lay their eggs in abnormal places in which they would never oviposit if their peace of mind had not been very greatly disturbed. Carter has advocated placing pots of water on verandahs in order that the female mosquitos may follow their sexual instincts without perversion; at the same time no breeding takes place, as the pots are emptied, dried and refilled once a week. A drawback to this method is that it must be done by a careful, methodical person or the pots may become breeding-places and larvae will adhere to the bottom of the pot and survive.

We have been fortunate enough to discover an improvement on this method, during an attempt to analyse the factors which cause *Aedes variegatus* (*Stegomyia pseudoscutellaris*) to lay its eggs in certain places and not in others. We find that infusions of hay, rice or bran, diluted and allowed to rot, are very attractive to this insect and also to *A. argenteus*, and that by poisoning the infusions one can bring about the death of the larva soon after it hatches from the egg, while the poison does not render the infusion less attractive.

The following experimental result (Tables I and II) illustrates this. The experiment was conducted on a verandah within ten yards of a patch of forest in which *A. variegatus* was breeding in large numbers, so that our experimental pots were competing, not only against one another, but also against numerous natural breeding-places. The pots were alike in every way and were covered with empty four-gallon petrol tins, each with a round hole three inches in diameter in its top, since we have found that these tins increase the attractiveness of the pots. To ensure uniformity, the position of the pots was changed periodically and the tin covers were exchanged. Every precaution was taken to make the results strictly comparable. The pots were of glass, 14 cm. in diameter and 10 cm. deep, with straight sides. When in use they contained about 500 cc. of the liquid under study; the depth of it was then about 4 cm.

The following liquids were used:—*Hay infusion*: This was made by boiling grass in sufficient water to cover it. A large quantity was made and sterilised; it was diluted when required to about twenty times its volume with tap-water, so that all the infusions used were of about the same strength and composition. A little primary sodium phosphate was added to the hay infusion to bring it to neutrality, but there is no evidence at present that neutralising made it more or less attractive. *Alkaline hay infusion and arsenic*: Hay infusion containing 0.05 per cent. of arsenious anhydride and sufficient $\frac{N}{10}$ sodium carbonate solution to make the pH. approximately 10. *Neutral hay infusion and copper sulphate*: Hay infusion containing 0.1 per cent. of copper sulphate and sufficient $\frac{N}{10}$ sodium carbonate solution to bring it to neutrality. *Distilled water*: This was replaced by fresh once a week. It was included as being a strictly standard control, which could be used in other countries.

The distinction between the eggs of *A. variegatus* and *A. argenteus* have already been described by us. The eggs are readily separated by the naked eye.

TABLE I.—*Number of Eggs (6 weeks).*

Liquid used.	<i>A. variegatus.</i>	<i>A. argenteus.</i>
Hay infusion	178	224
Alkaline hay infusion and arsenic	150	172
Neutral hay infusion and copper sulphate	162	217
Distilled water	22	67

TABLE II.—*Minimum Number of Layings.*

Liquid used.	<i>A. variegatus.</i>				<i>A. argenteus.</i>			
	1st fort-night.	2nd fort-night.	3rd fort-night.	Total.	1st fort-night.	2nd fort-night.	3rd fort-night.	Total.
Hay infusion	1	2	6	9	3	2	2	7
Alkaline hay infusion and arsenic	5	3	3	11	3	2	3	8
Neutral hay infusion and copper sulphate	2	2	6	10	3	2	4	9
Distilled water	1	1	0	2	2	2	2	6

It is not yet clear how one can best express the attractiveness of a pot to the female mosquito. The crude "number of eggs" (*a*) laid in a given period gives fallacious results because some females are prepared to lay a full batch of eggs, while others can only lay two or three even if the fluid is extremely attractive. This random error can be neglected if all the pots are exposed for a very long period. It is possibly better to record the "minimum number of layings" (*b*), that is to say, to examine the pots every morning and record *one* laying of a given species, however many eggs are found. This involves an obvious error, because several females may oviposit in one pot in a single night. Furthermore, the error is biased, because the chances that several layings will be recorded as one are greater with the attractive than with the unattractive pots. It is possible that the attractiveness of a pot would be more accurately measured by $\frac{a}{b}$ or by *a b*.

The minimum numbers of layings are given in the table for fortnightly periods as well as for the whole six weeks. It will be observed that the two poisoned infusions are as attractive as the untreated hay infusion throughout the time. This is an important point; the poisoning does not reduce the attractiveness of the infusion, either at first or later. The figures for "number of eggs" are only given for the whole period, because the random error discussed above makes the fortnightly figures valueless.

The poisoned infusions kill the larva within two days of emergence, generally in a few hours. The fluid must not be filtered because much of the copper is precipitated, probably as a carbonate, and is toxic in this form. It might be thought that the copper or arsenic killed certain elements in the microflora, and that the death of the larvae was due to starvation. This is not the case; larvae of the two

species of *Aedes* have been isolated in autoclaved distilled water, when they were less than half-an-hour old, and pipetted into fresh autoclaved distilled water every morning. Fifteen larvae of *A. variegatus* survived the following number of days :—

1 day : 3.	2 days : 1.	3 days : 2.	4 days : 6.
5 days : 1.	6 days : 0.	7 days : 1.	9 days : 1.
Average age at death : 3·7 days.			

We have similar figures for *A. argenteus*, but they show no essential difference; As the larvae survive longer in autoclaved distilled water than in poisoned infusions, we conclude that their death in the infusion is due to the poison and not to starvation.

We are continuing the work, endeavouring to find :—

1. Some fluid more attractive than hay infusion ; one wants a fluid which will retain its attractiveness over periods of months.
2. The minimum lethal percentage of poisons.
3. An efficient poison which would be less dangerous than white arsenic or copper sulphate to animals and children.
4. An insoluble poison which the larvae would pick up from the bottom, but which would presumably have no effect on the microflora.

Though much work remains to be done, we feel justified in publishing this note. Our figures show that the poisoned infusions are attractive to the female *Stegomyia*, and fatal to the small larva. Also the infusions remain attractive and fatal, for long periods, so that the method is almost automatic, and it appears that we have found a valuable subsidiary method for controlling *Stegomyia*.

It is pleasant also to think that the female mosquito will no longer be compelled by man to pervert her maternal instincts and lay her eggs in unsuitable places. The days of the crude sanitarian with his gang of oilers are numbered. Let him give place to the more refined and efficient student of the sexual psychopathies of the insects, and let the female mosquito divert her natural emotions to race suicide instead of to normal reproduction.

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Fig. 1 Branches of a peach tree heavily infested with Giant May-bug

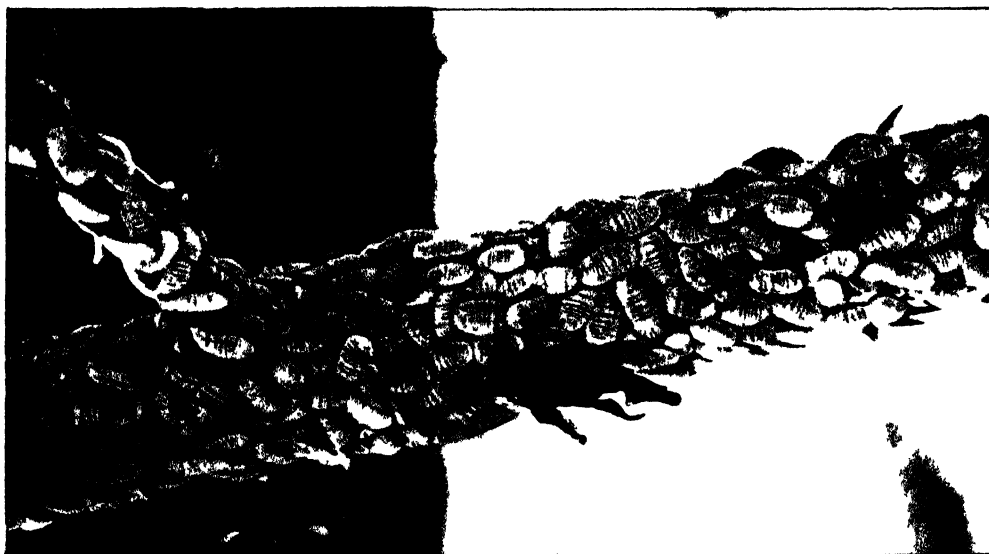


Fig. 2 A branch of the same tree more highly magnified





Dead *Monophlebus* (numbering about 11 000) at base of a peach tree after the fifth spraying

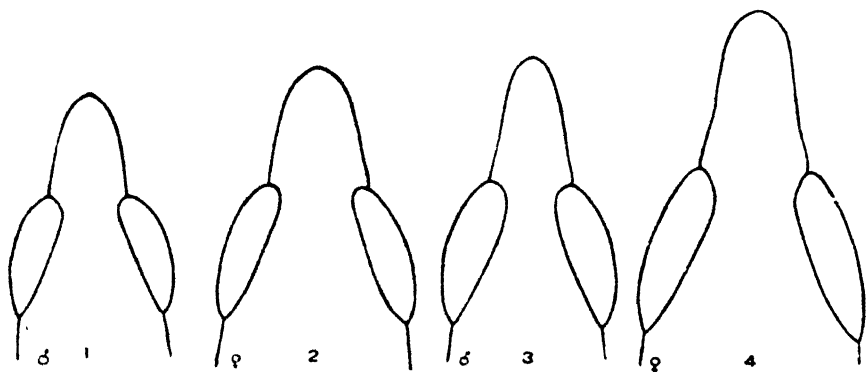
A NEW GRASSHOPPER INJURIOUS TO RICE IN SIAM.

By B. P. UVAROV.

***Quilta oryzae*, sp. n. (fig. 5).**

♀. Very slender, strongly resembling an *Atractomorpha* in general appearance.

Antennae basally somewhat dilated and slightly compressed, about half as long again as the head. Head conical, as long as pronotum. Face very strongly oblique, obsoletely punctured and with irregular subobliterate longitudinal rugosities. Frontal ridge between antennae raised, below ocellum very low, with the sulcus distinct throughout, widened at the fastigium; margins very obtuse. Eyes strongly elongate. Fastigium of vertex (fig. 4) about as long as an eye, and about half as long again as the basal width; its sides, seen from above, distinctly concave; surface convex, with a faint trace of the median carinula in the hind part, the carinula being better developed on the occiput.

Figs. 1-2. *Quilta mitrata*, Stål.Figs. 3-4. *Quilta oryzae*, sp. n.

Pronotum compressed laterally, as long as head. Upper surface distinctly convex, rugulose punctured; prozona nearly twice as long as metazona; median carinula in prozona replaced by a very fine sulcus, in metazona very low; hind angle very obtuse, its point rounded, truncate; lateral keels distinct in prozona, practically obsolete in metazona, straight, slightly divergent backwards. Lateral lobes much longer than high; their front margin strongly oblique, front angle very obtuse, lower margin ascending, very obtusely angulate just behind the middle, hind angle slightly less than 90°, rounded, hind margin sinuate. First and third transverse sulci dissect pronotal disc into three equally long parts; first not developed on the lateral lobes; second fine on the disc, well impressed and straight on the lobes, almost reaching their lower margin; third slightly sinuate on the lobes; the lobes with an additional sulcus near the front margin not extended on to the disc.

Prosternal tubercle strongly bent backwards, almost touching mesosternum, strongly pilose. Mesosternal interspace constricted in front of the middle, the margins strongly divergent backwards. Metasternal lobes connected along a straight line. Elytra extending well beyond the hind knees, pointed at the apex. Wings a little shorter than elytra.

Hind femora slender, gradually narrowed towards the apex; knees armed with two pairs of spines. Hind tibiae with the margins in the apical half strongly laminate-expanded. First tarsal joint also expanded.

Supra-anal plate almost covering the ovipositor. Upper valvae of ovipositor large, compressed, elongate-triangular, with the apex rounded; lower valvae armed with a spine just behind the middle, an apical spine and 2-3 smaller spines between those two. Subgenital plate with the apex trapezoidal. Cerci compressed, as long as ovipositor.

General coloration pale apple-green. Margins of fastigium and lateral postocular fasciae reddish brown. Pronotum with the lateral keels yellowish, with a narrow brown stripe adjoining the keels from below. Hind femora with 3-4 dark dots along the median line of the external face. Hind tibiae and cerci very faintly purplish. Wings hyaline.

♂. Fastigium of vertex (fig. 3) half as long again as the basal width, with the margins straight, distinctly divergent backwards. Mesosternal interspace parallel-sided. Cerci compressed, with the apex slightly attenuate and decurved. Subgenital plate small, narrowly conical, pilose. Green above, chocolate-brown laterally.

Total length ♀ (type) 31, ♂ (paratype) 23; pronotum ♀ 6.5, ♂ 4.5; elytra ♀ 27.5, ♂ 21; hind femur (measured without spines) ♀ 16, ♂ 11 mm.

Described from a female type, and three male paratypes collected by Mr W. R. S. Ladell at Klong Rang Sit, Bangkok, Siam, xii. 1924.



Fig 5 *Quilta oryzae*, sp. n.

The insects are reported by the collector to damage rice, and they may be easily separated from other grasshoppers occurring on the rice-fields by their very slenderly built, conical head and pointed elytra. The only genus liable to be confused with *Quilta* is *Atractomorpha*, which however differs from *Quilta* in a number of important characters, since it belongs to another subfamily. The principal difference between *Quilta* and *Atractomorpha* is in the structure of the prosternum between the front legs: in *Quilta* the prosternum bears a large recurved, inflated spine, while in *Atractomorpha* the anterior margin of the prosternum is only somewhat expanded into a transverse collar-like ridge. Further differences may be seen in an oblique row of granules on the cheeks of *Atractomorpha*, while the hind femora in that genus are without apical spines and the tibiae not expanded;* the ovipositor of *Atractomorpha* is of the type usual in short-horned grasshoppers, the upper and lower valvae being similar and without spines.

The colouration of the new species is not constant; two kinds of colouration are described above for the type and paratype, while another male paratype is reddish above and green laterally.

So far, only one species of *Quilta* was known, viz., *Quilta mitrata*, St., described from the Keeling (or Cocos) Islands in the Indian Ocean. Carl† recorded what he considered to be *Q. mitrata* from Java and Cochin China, but he did not compare his specimens with Stål's types, and the original description is not sufficiently exact

* In *Quilta* the expansion is an obvious adaptation for swimming.

† Revue Suisse de Zoologie, xxiv, no. 6, 1916, pp. 468-469.

to enable specific determination. Thanks to the usual kindness of Professor Y. Sjöstedt I received for study a male and a female co-types of *Q. mitrata* and their direct comparison with the Bangkok insect revealed some important points of difference which I feel justified in regarding as specific.

The main difference between *Q. mitrata* and the new species is in the shape of the vertex, as is obvious from the appended sketches made by the aid of a camera-lucida. Further, *Q. mitrata* is a smaller and less slender insect than *Q. oryzae*, with the pronotum shorter; the lateral lobes of pronotum in *Q. mitrata* are very distinctly shorter than in the new species, and their hind margin more strongly sinuate. The mesosternal interspace in the male of *Q. mitrata* is constricted in the middle, in the female practically parallel-sided, while in *Q. oryzae* these characters are reversed in the two sexes. The elytra in *Q. mitrata* are relatively distinctly shorter than in the new species. The genitalia of the two species do not show appreciable differences, though the male cerci of *Q. mitrata* have the apex slightly more attenuate and decurved.

As for the colouration, Stål's specimens were preserved in spirit and are discoloured, but they have been, apparently, of the same type of colouration as *Q. oryzae*; there are also faint traces of dark dots on the hind femora, not mentioned by Stål.

The species of *Quilta* recorded by Carl (*l.c.*) from Java seems to be nearer to *mitrata* than to *oryzae*, while another, from Cochin China, is said to have the hind knees black, and is possibly distinct.

THE GENERIC TYPES OF THE DIASPIDAE (HEMIPTERA).— INTRODUCTION.

By G. F. FERRIS,
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(PLATES XII-XIII.)

In spite of the notable economic importance of the scale-insects and in spite of their extraordinary biological interest, all of which has generated a very considerable activity in their study, it cannot be said that the systematics of the group are in anything that even approaches a satisfactory condition.

It is not necessary here to enter into any prolonged discussion by way of proof of this statement. The facts are well enough recognised by practically all of those who are actively engaged in the study of the scale-insects at the present time. Nor is it necessary to dwell at any great length upon the reasons for the existence of these conditions, for those reasons are fundamentally simple. Essentially the difficulty has been that the study of this group demands highly specialised methods and a specialised point of view. As a corollary of this there is demanded a highly specialised training on the part of the student.

The evidences of such specialised training that may be found in the work of all but a relatively small group of the students of the scale-insects are few indeed. It may fairly be said that while there have been many who have worked on the scale-insects, there have been few who have really known anything about them, and still fewer who have understood anything of what they knew.

It is especially desirable that in a group such as this, which is of extreme interest to others than systematists alone, the systematic work should be done with especial care. It is a group that appears constantly in economic literature. The names of some of the species are familiar to almost all entomologists. The exact determination of species is frequently of the most definite economic importance. It is above all in such a group that the best efforts of the systematist are demanded, and that stability of nomenclature, definiteness of description and accuracy of figuring are imperatively needed. It is precisely in this group that nearly all of these desiderata are quite generally lacking.

Of the approximately twenty-five hundred species of scale-insects that have been described probably not one-fifth can be identified from the literature within anything that even approximates to accuracy. The most fundamental facts of structure are frequently entirely ignored in descriptions and omitted from figures. There are but few of the genera that are at all accurately defined, and even the limits of some of the larger groups have been drawn with complete disregard of the fundamental morphological characteristics. And the nomenclatorial situation is quite in keeping with this condition.

Of the larger groups, those that have usually been called sub-families, one of the largest and most important is that of the Diaspids, a group that I here regard as a family, the DIASPIDAE, of the super-family COCCIDOIDEA. It is also generally regarded as probably the best known of the Coccid groups. Yet here we have a most distressing situation. The older authors, working almost exclusively from the characters afforded by the scale-covering and not from the structure of the insects themselves, have recognised but a relatively small number of genera. In the majority

of cases it is evident that these so-called genera are simply heterogeneous assemblages, frequently of quite unrelated forms. In some genera attempts at naming subgenera have been made, usually only to be ignored.

Into this situation of extreme conservatism there has been injected the work of a recent author who has named over a hundred new genera in this group alone. Many of these genera are undoubtedly valid, many others are with equal certainty synonyms. The work of this author was based almost exclusively upon the existing literature, unchecked by any genuine knowledge of more than a very few of the insects themselves. I have reviewed this work elsewhere and need not here repeat my criticisms. Were I to do so it would be merely to strengthen them. It is enough to say that the situation as it exists at present verges on the impossible.

I can see but one way of escape from this condition, and that begins with a study of the types of the genera. There must be a search for the actual structural characters that are available; the types, which are the anchors of the genera, must be reviewed in order to determine their exact characteristics; there must be then a reorganisation and a re-allotment of the species to those genera that appear actually of value; the trash must be discarded.

As a beginning of this programme I have initiated such a study of the generic types of the DIASPIDAE, of which there are about two hundred. It is obvious that such a task will take time, and at present it appears that the only practicable way of accomplishing it is to proceed genus by genus, publishing the results as they become available in a series of short papers. It will not be practical in these papers to deal with the males, although undoubtedly no really final study can be made until they have been considered. However, the classification of these insects will probably always be dependent upon the females rather than the males, because of the difficulty of obtaining the latter. Actually the study of the males is a separate problem and it will here be so regarded. Consequently, except for the scale-covering, the females alone will be considered in these papers.

The ideal toward which our efforts will be directed is that of so describing, and above all of so figuring, each species that any reader of these papers will have available all the data necessary for the formation of conclusions as to the identity of species and the value of generic characters.

The types of the older and more comprehensive genera, the "mother genera," as it were, from which the majority of the smaller genera have been derived by nomenclatorial splitting, will be considered first.

Other genera will be considered as material becomes available. The resulting papers will be published in convenient units. They will in all probability be by a series of different authors, but every attempt will be made to maintain a uniform standard and a uniform type of treatment.

There follows the first paper of the series, by Mr. L. Emery Myers, dealing with the types of the genera *Aspidiotus* and *Diaspis*.

PART I.—THE GENOTYPES OF *DIASPIS* AND *ASPIDIOTUS*.

By L. EMERY MYERS.

1. Genus *Diaspis*, Costa.

According to the Fernald Catalogue the type of this genus is *D. calyptroides*, Costa, this being a synonym of *echinocacti* (Bouché). According to MacGillivray (The Coccidae, p. 320) *echinocacti* is a synonym of *calyptroides*. We accept the views of the former author.

***Diaspis echinocacti* (Bouché) (Plate xii).**

SCALE. *Female* (Plate xii, fig. 3) 1-1.5 mm. in diameter, circular or sub-circular, slightly convex, white, felted; exuviae central or sub-central, covered with a slight film of wax; ventral scale consisting of a mere film, which remains attached to the host. *Male* (Plate xii, fig. 2) about 1.5 mm. long and 0.5 mm. wide, white, non-carinate, felted, in texture similar to that of the female, exuviae at one extremity; ventral scale quite thick, together with the dorsal scale entirely enclosing the insect.

Exuviation occurring by the rupturing of the ventral derm between the antennae and the mouth-parts, the ventral skin being pushed back to the posterior end, the antennae remaining attached to the dorsal portion, which becomes heavily chitinised.

MORPHOLOGY OF THE FEMALE. *Adult female* (Plate xii, fig. 1) about 1 mm. long; derm membranous throughout except for the pygidium, about half the body formed by the anteriorly rounded cephalo-thorax; abdomen quite strongly constricted inter-segmentally, the marginal lobes quite prominent.

Antennae consisting merely of a small tubercle bearing a single seta. Spiracles simple, without accompanying pores.

Tubular ducts abundant, consisting for the most part of a single definitive type, which appears to be characteristic of the species that may be grouped about the genus *Diaspis* as contrasted with those that may be grouped about *Aspidiotus*. The ducts of this type are characteristically short and relatively broad, and are marked at their inner extremity by two distinct, parallel, transverse bars, which are their most distinctive feature. They may be designated as the diaspine type, or if a descriptive term is desired, as the two-barred or bifasciate ducts. They vary in size, those at the margin of the pygidium being noticeably larger than those over the surface of the pygidium, and these in turn larger than those on the ventral side of the body, but there is no distinction in actual type. A minor distinction may be made between those at the margin of the pygidium and the others, for the marginal ducts have their mouths more or less parallel to the longitudinal axis of the body, while the others have them transverse. The two forms are shown in Plate xii, fig. 11 and fig. 12.

It may here be noted that we cannot concur in the interpretation of these structures given in a recent paper by Miss Hoke. This author has described the ducts as having their orifices covered by a flap. We are convinced that no such flap exists, and that Miss Hoke has simply misjudged the manner in which the walls of the duct connect with the outer wall of the body. The orifices are frequently enclosed within a chitinous ring, as indicated in our figures.

In addition to the ducts of this type there are present a small number of extremely minute ducts, so small that their exact structure cannot definitely be determined. The greater portion of these ducts open near the apex of membranous processes (Plate i, fig. 8) to which an earlier author has applied the term "gland spines," a term that we retain. These gland spines, it may be noted, appear also to be distinctive features of the genera that may be grouped with *Diaspis* and are not found in those of the aspidiotine type. A very few similar ducts are distributed over the surface of the body where they do not thus open through gland spines.

The large marginal ducts of the pygidium, thirteen to fifteen in number in this species, for the most part have their orifices borne upon slight processes, to which an earlier author has given the term "gland prominences," a term that we retain.

The distribution of the various ducts is clearly indicated in the accompanying figures (Plate xii, figs. 1, 9, 10), and need not be discussed in detail. It should be noted, however, that the ducts of the pygidium are more or less irregularly distributed, showing almost no tendency to be arranged in definite rows. Gland spines are present at the margin of the two pre-pygidial abdominal segments, as well as on the pygidium.

Paravaginal pore groups five in number, the groups rather small, the pores of the type shown in Plate xii, fig. 6.

Margin of the pygidium (Plate xii, fig. 9) with four pairs of lobes. Median lobes not sunk into a notch, as MacGillivray has quite erroneously stated; rather widely separated; second to fourth pairs all bilobed, the outer lobule the smaller; median lobes and inner lobule of all the others with a pair of small paraphyses projecting into the body. Marginal setae with the bilobed thickenings about their sockets that are characteristic of all the Diaspids; these not enlarged.

Second stage of female. In general quite like the adult; pygidial margin (Plate xii, fig. 5) the same, except that there are but eight large marginal ducts; tubular ducts other than those of the pygidial margin practically lacking, those which are present very small. Paragenital pore groups lacking, as is the case in all Diaspids of this stage.

First stage of female (Plate xii, fig. 7). Of a general type that is common to all Diaspids. Antennae (Plate xii, fig. 14) six-segmented, the terminal segment not elongate and not annulate. Body entirely without large ducts, the margins with series of minute ducts, the pygidial area with two pairs of gland spines. Two pairs of pygidial lobes present, widely separated, the mesal pair completely divided into two lobes.

2. Genus *Aspidiotus*, Bouché.

According to the Fernald Catalogue the type of *Aspidiotus* is *A. nerii*, Bouché, which is a synonym of *hederae* (Vallot). This is a species that has been described many times under many different names, and there may be some doubt as to its actual identity, for a careful comparison of a long series of specimens from various hosts and localities shows a considerable degree of variation. It is not impossible that actually several very closely related species are included under this name, although we have been unable to find any satisfactory basis for their separation.

For the purposes of this paper we have utilised specimens taken from *Hedera helix* in California, which seem to agree very closely with specimens from strawberry in Italy. Even if it should later be demonstrated that actually these specimens do not represent the true *Aspidiotus hederæ* it is not likely that any difficulty will arise in regard to the generic characters.

Aspidiotus hederæ (Vallot) (Plate xiii).

SCALE. *Female* (Pl. xiii, fig. 7) 1-1.5 mm. in diameter, circular, slightly convex, white or slightly grey; exuviae central, covered with a film of wax; ventral scale consisting merely of a powdery film, which remains on the host. *Male* (Pl. xiii, fig. 6) somewhat elongate, oval, length 1.5 mm., width 1 mm.; texture as in the female; exuviae, central or subcentral; ventral scale a thin film, which remains attached to the host.

Exuviation occurring as in *Diaspis echinocacti*, by the rupturing of the ventral derm between the antennae and the mouth-parts.

MORPHOLOGY OF THE FEMALE. *Adult female* (Pl. xiii, fig. 1) about 1 mm. long; general form deltoid; derm membranous throughout except for the pygidium; intersegmental constrictions slight or nearly obsolete, the lateral lobes of the abdominal segments not protruding, the greater part of the body formed of the cephalothoracic region.

Antennae consisting merely of a slight tubercle bearing a single small seta. Spiracles simple, without accompanying pores.

Tubular ducts confined for the most part to the pygidium, consisting of a single type, although variable in size. This type may be regarded as characteristic of the species that may be grouped about the genus *Aspidiotus*, as contrasted with those

that may be grouped about *Diaspis*. In *Aspidiotus hederæ*, and in a few closely related species, these ducts depart from the form found in most of the other aspidiotine species in that the ducts are short and broad, as much so, in fact, as in *Diaspis*, while in the majority they are typically long and slender. They are, however, characterized in all the aspidiotine forms by the presence at the inner extremity of but a single distinct bar (Pl. xiii, figs. 3, 4). It is true that there is usually a faint shadowy indication of chitinization that might be regarded as a vestige of a second bar, but, nevertheless, the examination of a long series of species has convinced us that there are actually fundamental differences between this type and that found in the species of the *Diaspis* group. It may be referred to as the aspidiotine, or one-barred, or unifasciate type. As indicated by figs. 3 and 4, there are in *Aspidiotus hederæ* two markedly different sizes of ducts, those of the smaller size being confined in general to the margins of the body and to the ventral side of the pygidium.

The distribution of the tubular ducts on the pygidium is as indicated in Pl. ii, fig. 8. It may be noted that the chief difference among the many specimens examined is to be found in the numbers of these ducts, in some specimens there being nearly double as many as are shown in the figure.

Paravaginal pores in four groups, the two groups on each side being linked by a narrow, chitinized area.

Margin of the pygidium (Pl. xiii, fig. 9) with three pairs of lobes. The median pair are slightly separated, prominent, rather narrow and continuous with a small, heavily chitinized area that extends from each into the pygidium. The second and third pairs are of the same general shape as the first, but are smaller.

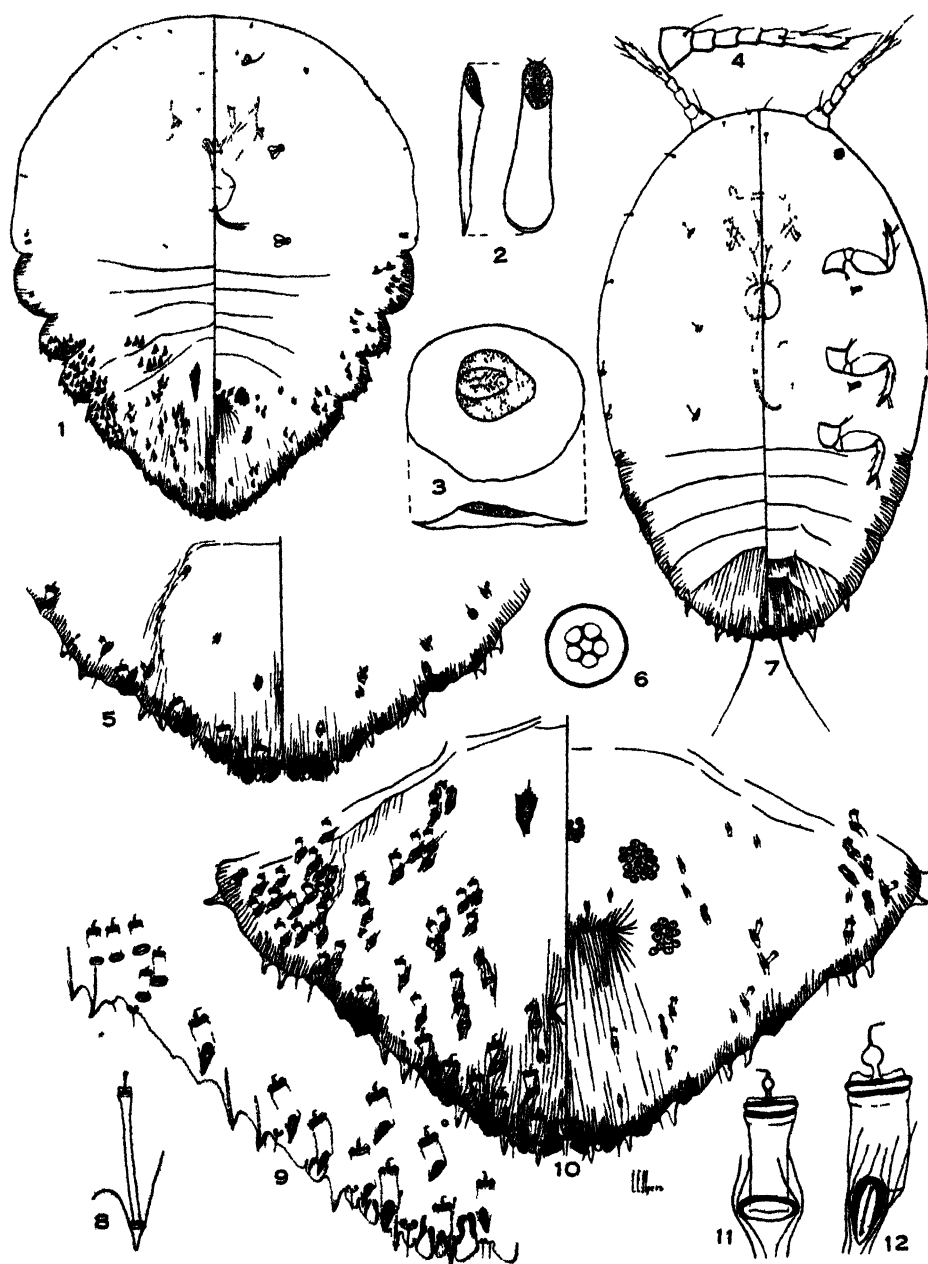
The fringe of processes, which are referred to by various authors under many names, but for which we shall use the most commonly employed term "plates," is quite distinctive of the species. The plates are large and conspicuous, arranged as indicated in Pl. xiii, fig. 9, and are characterized particularly by the many and deep serrations and divisions of their lateral and distal margins.

Anal opening removed from the apex of the pygidium by about a third of the length of the latter.

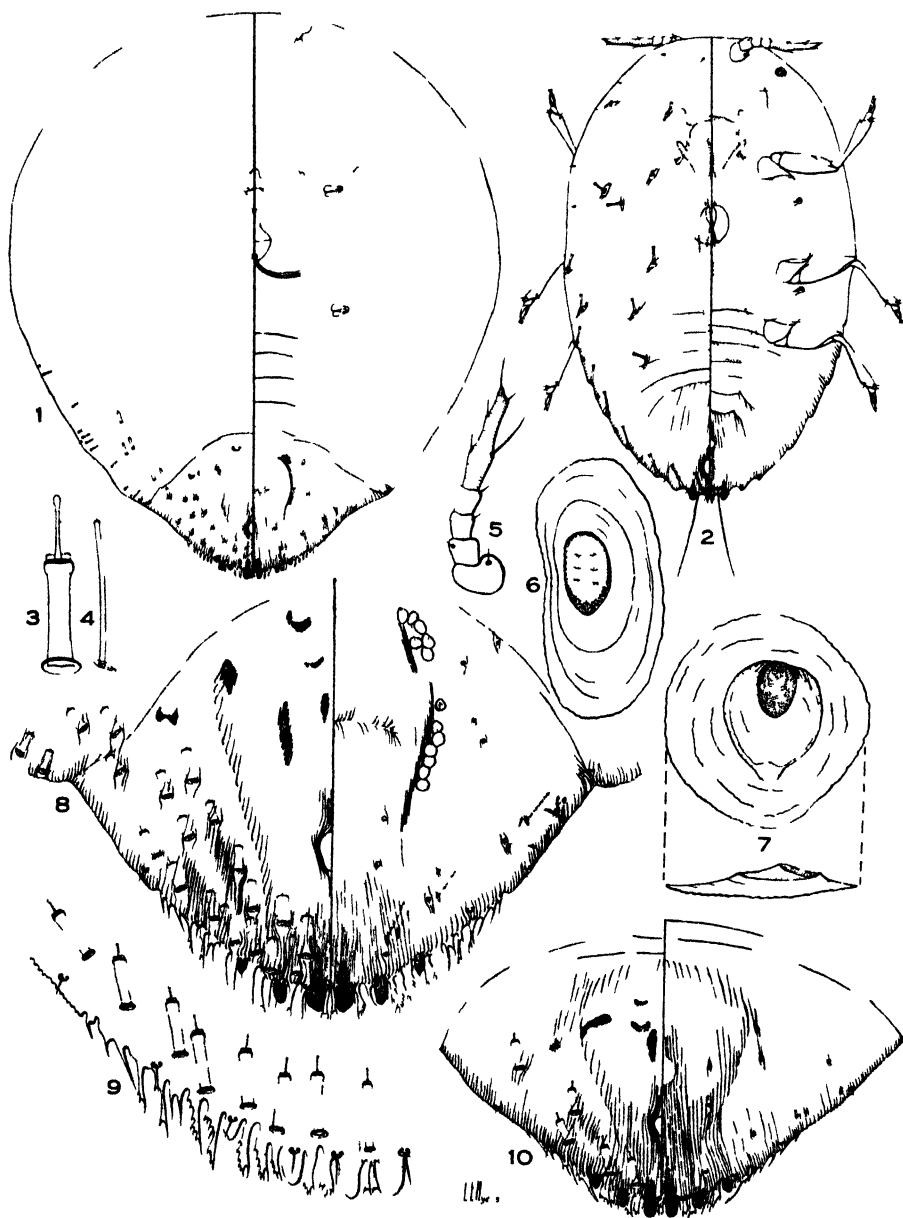
Dorsal side of the pygidium with several rather heavily chitinized patches, which are possibly points of origin of muscles, and are quite characteristically arranged.

Second stage of the female. In general, quite closely resembling the adult. Pygidium (Pl. xiii, fig. 10) with somewhat fewer ducts and plates, and without the paravaginal pore clusters.

First stage (Pl. xiii, fig. 2). Antennae (Pl. xiii, fig. 5), five-segmented, the fifth segment considerably elongated and distinctly annulate. Margins of the body with nine small tubular ducts on each side. Dorsum likewise with several small ducts. Pygidium with a single pair of quite prominent lobes.

*Diaspis echinocacti* (Bouché)

- | | | |
|---------------------------|--|----------------------------------|
| 1 Adult ♀ | 5 Pygidium of second stage ♀ | 8 Gland spine |
| 2 Scale of ♂ | 6 Type of spore from perivaginal spore cluster | 9. Margin of pygidium of adult ♀ |
| 3. Scale of ♀. | 7 First stage | 10 Pygidium of adult ♀ |
| 4. Antenna of first stage | | 11, 12 Tubular ducts. |



Aspidiotus hederæ (Vallot)

- | | |
|-----------------------------|-----------------------|
| 1 Adult ♀ | 6 Scale of ♂ |
| 2 First stage | 7 Scale of ♀ |
| 3 4 Types of ducts | 8 Pygidium of adult ♀ |
| 5 Antenna of first stage | 9 Margin of same |
| 10 Pygidium of second stage | |

ENTOMOLOGICAL ANALYSES OF TREES.

By IVAR TRÄGÅRDH, D.Sc.,

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In a previous paper, "On the use of experimental plots when studying forest insects" (Bull. Ent. Res. x, pt. 2, Jan. 1920), the author emphasised the necessity of using every effort in order to obtain accurate records of the degree of infestation and amount of injury of forest trees. During recent years the author has developed a method of recording and graphically illustrating the part played by different insects in killing a tree. This method having yielded very good results, he proposes here to bring it to the notice of other entomologists, especially those interested in forest insects.

To the forest entomologist, examining dead or dying trees, two important questions persistently present themselves to which it is often very difficult to give proper answers. One is: Which insect started the attack? The other is: Why did the insect in question choose this tree instead of its neighbour?

These questions go to the very heart of the matter, since it is obvious that if we know exactly what type of tree is liable to be attacked by a certain insect, it may be possible to prevent the attack by managing the forest in such a way as to prevent that kind of tree from appearing.

In order to learn this, two things at least are necessary: an extensive series of analyses of dead or dying trees, recording the way in which the different insects succeed one another, and experimental plots in order to watch the attack from the very beginning. By combining the results obtained by these two methods with a thorough analysis of the condition of the stand where the trees are growing, the soil, and the growth of the tree by means of an increment borer, it will, it is hoped, eventually be possible to formulate better founded opinions regarding the activity of the injurious forest insects than is at the present time possible.

When making analyses of the fauna of dying trees it is desirable to start as early as possible in the season, when as yet only the poorly developed shoots enable us to pick out, by means of field-glasses, the trees that have, during the previous summer, been more or less seriously damaged. At this time of the year there is obviously no difficulty in distinguishing between the attacks started during the previous year and the new ones made in the spring, whereas in the autumn, when perhaps all insects are gone, it may be rather difficult or even quite impossible to say with certainty which attack started, say, in 1924, and which in 1923.

The tree to be analysed having been cut down, the measurements of the height, diameter, size of the crown, thickness of the bark, and other characteristics in different parts of the trunk are recorded, the entire tree being afterwards thoroughly examined after the bark has been removed, and the distribution of the tunnels and injuries caused by the different insects being carefully recorded. It is imperative that the entire bark should be removed, especially at the base of the tree, because otherwise it may happen that attacks of small size, but, nevertheless, of great importance for studying the sequence of the different insects, are overlooked, in which case the whole analysis is worthless for the purpose of finding out the general principles that underlie the activity of the insects.

For the purpose of recording graphically the results of the analyses the author employs a figure showing the tapering of a stem, the form class value of which is 0.7 per cent., which means that the diameter taken at a point halfway between the top and breast height is 70 per cent. of the diameter at breast height. This form class is chosen because it is fairly representative for the forests as a whole, but it is obvious that other figures representing other form class values may be used.

The accompanying figures show some results obtained by this method. At Kalleberga, in the province of Scania, in the south of Sweden, the pine-beetles (*Myelophilus piniperda* and *M. minor*) were very common in a pure stand of pine trees of about 50 years old, a number of trees succumbing every year to the attack of these insects without anybody being able to tell why the beetles were so persistent and successful. A series of analyses (fig. 1) revealed the fact that the attacks of the pine-beetles had in almost every case been preceded by an attack of the one-banded pine-weevil (*Pissodes piniphilus*) and the larger pine-weevil (*P. pini*). Of these

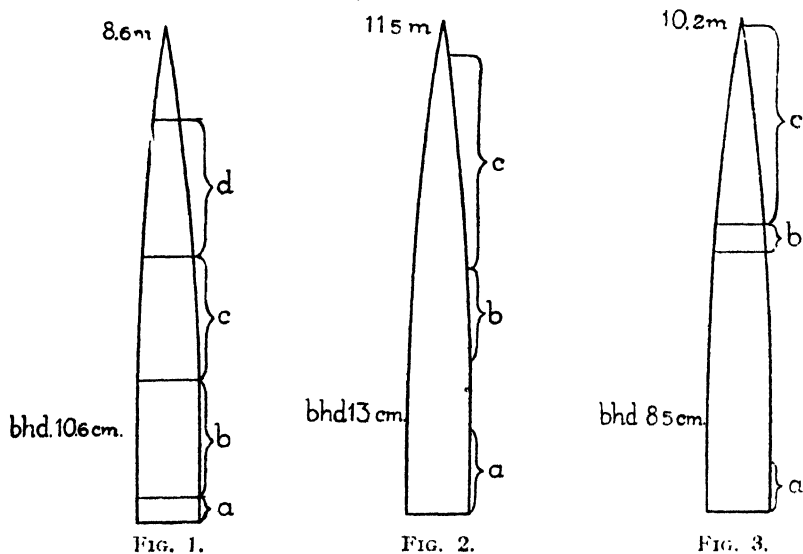


Fig. 1. Analysis of a dying pine tree at Kalleberga, June 1923, attacks of: (a) *Pissodes pini*, 1922; (b) *Myelophilus piniperda*, 1923; (c) *M. minor*, 1923; (d) *Pissodes piniphilus*, 1922.

Fig. 2. Analysis of a dying pine tree at Särna, Dalecarlia, August 1923, attacks of: (a) *Myelophilus piniperda*, 1922; (b) *Carphoborus cholodkovskyi*, 1923; (c) *Pissodes piniphilus*, 1921.

Fig. 3. Analysis of a dying pine tree at Gyljen, Norrbotten, July 1922; attacks of: (a) *Myelophilus piniperda*, 1922; (b) *Peridermium pini*, culminating in 1920; (c) *Pissodes piniphilus*, 1921.

the attack of the latter was often confined to the base of the tree, and to one side of the trunk, the area attacked being not more than 2-3 cm. long, whence it is almost certain that a less thorough analysis of the trunk would have failed to reveal the attack. The one-banded pine-weevil, on the other hand, occurred in the crown of the pine-trees. From the analyses it is evident that in this instance the pine-beetles follow after the pine-weevils, and that the campaign must be directed against the latter, which are the primary cause of the injury.

This feature, that the different insects succeed one another in quite a definite manner, is still more evident when we consider the next analysis. Fig. 2 shows the results from a dead pine-tree at Särna, Dalecarlia. We notice that in this instance

also the one-banded pine-weevil started the attack in the crown, in 1921, the larger pine-beetle following in 1922, its attack being, however, restricted to the nethermost 1.8 m. of the trunk, only this part being covered by the rough bark which this beetle prefers. In company with *Myelophilus piniperda* were a few *M. minor*, the rest of the trunk escaping injury, probably owing to its slenderness. In 1923 this part of the trunk, which was at that time of course rather dry, became attacked by a

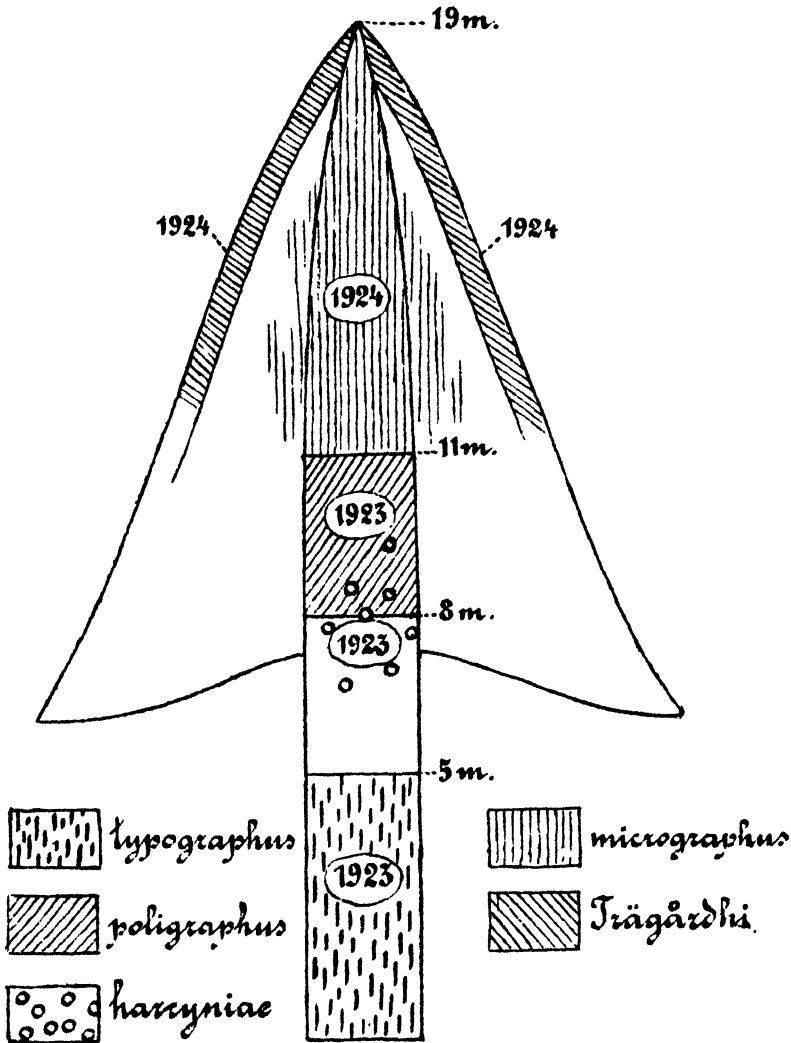


Fig. 4. Analysis of the trunk and crown of a dying spruce tree.

little bark-beetle, *Carphoborus chodkovskyi*, incidentally new for Sweden. In this instance the death of the tree was brought about by three different insects following one upon the other during three years. It seems obvious that if, for instance, the finding of *Carphoborus chodkovskyi* is accompanied by a series of such analyses recording the circumstances under which the beetle was found, it tells us far more concerning the biology of that species than the mere record, "found on a dead pine-tree."

The next analysis (fig. 3) shows that sometimes it is a parasitic fungus, in this instance *Peridermium pini*, which prepares the way for the insects. Just below the crown, at a height of 6.6–7.4 m. there were great wounds in the bark caused by this fungus. In 1921 the attack of the fungus had weakened the resistance of the pine to such extent that the one-banded pine-weevil succeeded in breeding in the crown, and in the following year *Myelophilus piniperda* followed, confining its attack, however, to the lowest part of the trunk (1–2 m.), the obvious reason for this being, as in the case described above, the small size of the tree, which measured only 8.5 cm. at breast-height, and the consequently small area covered by rough bark, below which the galleries of the pine-beetle are usually to be found.

The next figure (fig. 4) illustrates the analysis of a dying spruce-tree at Siljansfors, Dalecarlia, the investigation being made on 1st July 1924. In 1923 the lowest part of the trunk up to 5 m. was attacked by *Ips typographus*, and in the same summer *Polygraphus poligraphus* attacked in company with *Pissodes harcyniae* the trunk from 8 to 11 m. above the ground, pupae and imagines being found in 1924. From 11 m. above the ground *Pityogenes micrographus* attacked the spruce in 1924, and in the thinner twigs in the upper part of the crown, which still carried yellowish-green needles, *Pityophthorus trågårdhi* was breeding.

The analysis tells us that *Polygraphus poligraphus* sometimes attacks the spruce in the same year as *Ips typographus*, and thus replaces *Pityogenes chalcographus*.

It shows also the method employed in order to record which parts of the crown are subjected to attacks from different insects. The next figure (fig. 5) illustrates the result of several analyses, and therefore gives a general idea of the way in which the different species of bark-beetles succeed one another in the course of time, and shows at the same time that they choose quite distinct parts of the trunk and the crown.

These examples of this method of analysing seem to me to show that by accumulating numerous records of this kind we may be able to define more clearly the different ways in which the insects succeed one another when attacking the trees and gather reliable information regarding their relative importance.

The objection may, of course, be raised that we still do not know enough to be able to tell why a particular tree was killed by certain insects. That is quite true, but on the other hand we have taken one step nearer towards the solution of this problem, and, as a matter of fact, the information gathered regarding the importance of *Pissodes piniphilus* by means of these analyses bore fruit in a quite unexpected way last summer. From Värmland there had been reported during the summer of 1923 a severe attack chiefly of *Myelophilus minor* on pine-trees. As a rule such outbreaks are associated with irrational treatment of the forest, either through neglected thinning or by the failure to remove at the proper time the felled trees, or such trees as had fallen owing to storms or snow-pressure. In this instance it was not possible to connect the outbreak with any such feature. Other pressing engagements prevented my visit to the place in 1923, and in August 1924, when the locality was visited, the dead trees had all been cut and removed, only the tops being left. On examining very carefully the remaining trees it was noticed that the foliage of some of them had not quite the same dark green colour as the others, but showed just a slight trace of discoloration. The difference was, however, so exceedingly small that it would have been impossible to discern it had not one's attention been directed towards finding some traces of the outbreak. Some of the trees were cut and revealed the fact that *Pissodes piniphilus* was breeding in all the branches and in the tops of these trees, but as yet no other insects had started attacking them, not even *Pissodes pini*, which in other instances had been found attacking the basal portion of the trunk, nor were any injuries of parasitic fungi present. This observation suggests that the primary cause of the attack of the

one-banded pine-weevil was some climatic influence. And, as a matter of fact, the pine-trees grew on a poor, sandy soil where the ground-water surface was probably low and the balance of the supply of water to the trees might easily be disturbed. An examination of the yearly amount of precipitation in this part of Sweden revealed the interesting fact that in the years 1920-1922 it diminished from 781 mm. to 652 and 572 mm.

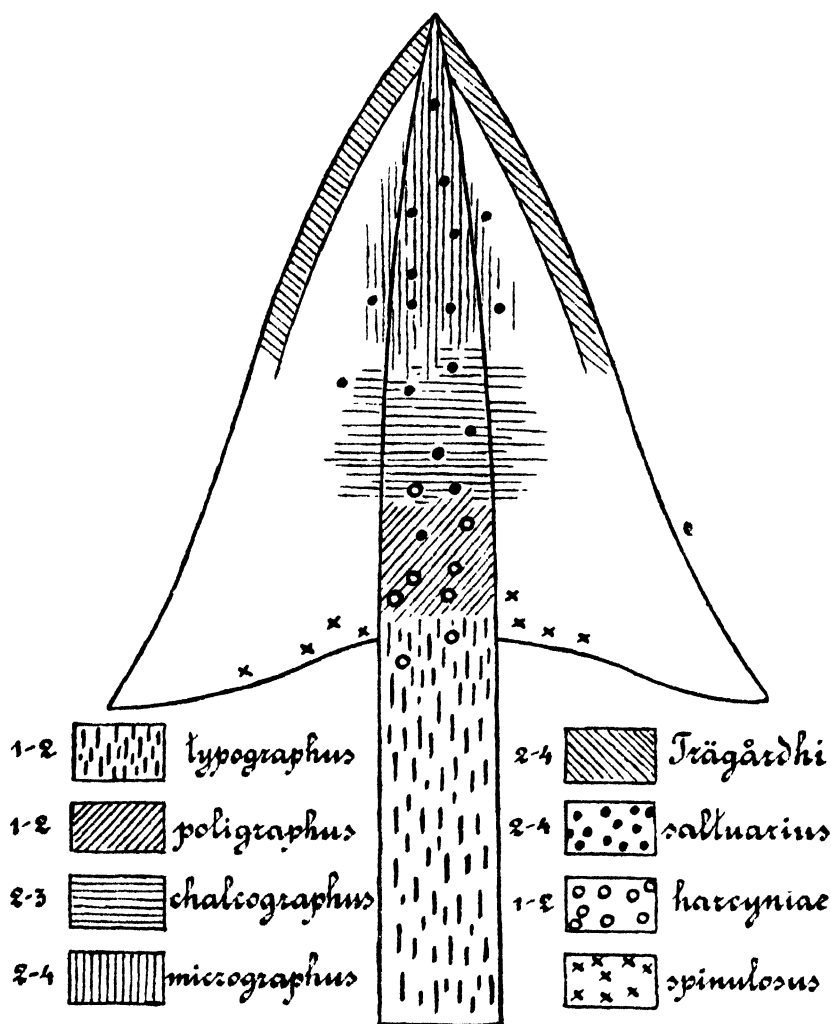


Fig. 5. Diagram illustrating a number of analyses of spruce trees, and showing the sequence of the different insects and their distribution in the trunk and crown, viz.: *Ips typographus*, *Polygraphus poligraphus*, *Pityogenes chalcographus*, *Pityophthorus micrographus*, *Pityophthorus trögårdhi*, *Cryphalus saltuarius*, *Pissodes harcyniae*, *Phthorophloeus spinulosus*; 1-2 - first and second year, etc.

Experimental plots may also with great advantage be employed, not only for recording the degree of infestation and the subsequent amount of injury to the tree, but also for the purpose of obtaining accurate records as to what kind of tree a certain insect attacks. The accompanying plan (fig. 6) illustrates this. The experimental plot was laid out in a pure stand of pine, about 50 years old, which had been attacked

by the nun-moth (*Lymantria monacha*) in 1915-17. The purpose was to study the effect upon the growth of different degrees of defoliation, and to see which trees eventually succumbed to the attack. The figure shows the condition at the revision in 1923. Of the 43 trees only 5 were killed, but all of them had succumbed to the attack of the pine-beetle (*Myelophilus piniperda*). We noticed at once that these trees had poorly developed crowns, partly overshadowed and suppressed by the



Fig. 6. Experimental plot laid out in a 50-year-old pure pine stand defoliated by the nun-moth (*Lymantria monacha*) in 1915-1917, and revised in 1920 and 1923. The dotted lines show the circumference of the crowns; the shaded areas are the trees which during the time, 1917-1923, were killed by the pine-beetle. The scale for the trees is 4 times that of the ground.

nearest trees, and, as a matter of fact, were exactly of the same type as those pines which, even in stands not previously attacked by defoliating insects, are picked out by the pine-beetle. The analysis in this instance seems to show that the attack of the nun-moth in a pure pine stand is not a serious menace to the trees. As a matter of fact there is no reason to believe that the attack had made the five trees liable to the attack of the pine-beetle, which undoubtedly in every case would have attacked them because, on account of the neglected thinning (evident from the circumference of the crowns), they had lagged behind the others and were doomed.

A SIMPLE FORM OF DISTRIBUTOR FOR INSECTICIDE DUSTS.

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and

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For some years past, when using insecticide dusts on a small scale, we have employed a very simple, improvised apparatus as a distributor, which has given such satisfactory results that we venture to describe it.

The apparatus is shown in the sketch (fig. 1). A glass jar, 13 ins. in height by 6 ins. in diameter, serves as a container and is closed with a tightly-fitting rubber bung, pierced with two holes, each to take a $\frac{1}{4}$ -in. bore glass tube. One tube (A) is long enough to reach nearly to the bottom of the container, but the other (B) is cut off just below the lower surface of the bung. Above the bung, tube A is elbowed, while tube B is either straight or elbowed depending on the purpose for which the apparatus is being used. The dust, to a depth of two or three inches, is placed in the container, and tube A is connected by means of a length of rubber tubing with a bellows. On working the bellows a current of air is forced in under the dust, and the atmosphere in the upper part of the container becomes heavily charged with the dust in suspension. This dust-laden air is driven out through tube B.

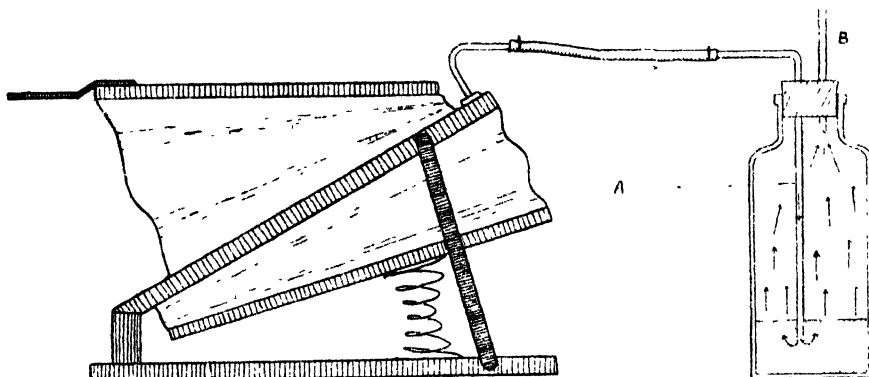


Fig. 1. A simple dusting machine.

When using the apparatus for fumigating a room (as for the destruction of bats with calcium cyanide) tube B is straight, and the container is placed on a stool or table in the centre of the room. The rubber tubing is long enough to pass through a window or other opening, and so permit of the bellows being worked from outside the room.

When it is required to apply a dust to an ants' nest or rats' burrow, one end of a length of rubber tubing is affixed to the mouth of tube B, which is elbowed, and

the other end is introduced into the entrance of the ants' nest or rats' burrow, as the case may be. To ensure that the dust-laden air passes into the nest or burrow, the entrance round the rubber tube is sealed with mud.

When the apparatus is needed as a knapsack duster we have obtained satisfactory results by substituting a cylinder of compressed air for the bellows.

The advantage of this type of dust distributor is its extreme simplicity ; there is nothing to get out of order which may not readily be repaired in the field. It is advisable that the bung should be wired to the neck of the container, as otherwise it may be blown out, and similarly that the junctions of the rubber and glass tubing should be bound with wire. When not in use the rubber tubing is disconnected from the bellows and temporarily affixed to tube B, to prevent the dust from absorbing moisture from the air.

The density of the dust cloud produced depends on the pressure of air employed and, to a less extent, on the height of the container.

We are indebted to Mr. W. W. Bowen for the illustration.

MIGRATION AS A FACTOR IN PEST-OUTBREAKS.

By T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
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Human experience in the past has often been crystallized into homely saws, of which the one that states that "Prevention is better than cure" should be regarded as one of the foundation stones of all work in economic entomology. We see this put into practice in such routine measures as the destruction of mosquito and fly larvae, ploughing fields in the dry weather to destroy grasshopper egg-masses, the destruction of weeds and stubble, the collection of egg-masses, caterpillars and hoppers, the enforced removal of cotton-plants after harvest, legislation against the introduction of pests into new countries, and similar measures which are so familiar that they need not be enlarged on here. Such measures are directed to and, if applied consistently, are largely effective in keeping within bounds insects which, if not thus checked, normally attain to destructive numbers, and by "normally" I mean that on the average they occur in such numbers every year, or for a series of years. There are, of course, fluctuations, due to natural causes, in the pest-status of many insects, which may be insignificant in normal years and occasionally rank as bad pests, or *vice versa*; of such causes we know as yet very little, beyond the pious ascription of them to the effects of parasitic control or climate. But, after eliminating these fluctuations, we still often find our expectations upset by outbreaks for which it is very difficult to invoke any adequate explanation other than that they are the effect of a large influx into the area affected of the insect concerned. Such a theory may appear far-fetched at first sight, especially as it is very difficult of proof in most cases, but we find in India an accumulation of cases for which such an explanation seems the only one possible.

The migration of insects is, of course, merely an accentuated form of dispersal by flight, which is more or less normal in the case of most winged insects. It is not usually realized what an important and constant factor this dispersal is. We are apt to picture to ourselves the insect fauna of a restricted locality—it may be a garden or a field growing the same food-plants more or less constantly, or it may be a larger, but still relatively restricted area—as practically confining itself to such a locality, since there is no incentive to leave it so long as the food-supply is accessible and sufficient. To a considerable extent this picture is a true one, and practical control-measures, such as rotation of crops, which are largely successful in practice, are based on this assumption. At the same time there is a constant diffusion of individual insects beyond the limits of each particular breeding-area. It may be that the conditions for existence of the species are for some reason unsuitable outside of it; in such cases the breeding area is restricted, as we see in the case of some British butterflies and moths, which are found in very restricted habitats, often apparently no different from the surrounding country. In other cases, where the contiguous areas are equally suitable for the breeding of the species concerned, as the distribution of the insect is continuous, it becomes extremely difficult to notice such dispersal unless it becomes conspicuous by occurring *en masse*, *i.e.*, as migration. Where the areas, however, are not contiguous, such dispersal of individuals is more easily noted. Islands, of course, form ideal observation grounds for the dispersal of insects, and it is in connection with their arrival in islands, or similar sea-surrounded areas, such as offshore lighthouses or ships, that most observations of this sort have been made. Twenty years ago, when investigating the insect fauna of certain islands in the Indian Ocean, I was attracted to this subject and attempted an analysis of the means

of dispersal of insects in such cases. Subsequently, when employed in 1906-1909 in a surveying ship off the Coast of Ceylon, we often used to anchor at night several miles off the coast, just wherever we happened to be on our line of soundings at the end of each day's work, and I then had occasion to observe the very large numbers of insects that flew on board the ship, many of them very small and apparently weak-winged species which would seem incapable of such a sustained flight. There was, of course, nothing new in such observations, except perhaps for the emphasis on the regular and unexpectedly extended dispersal of so many small insects, which I ascribed as mainly due to the action of upper air-currents, the wind at sea-level being often absent or even contrary. Similar unexpectedly extended effects of wind-dispersal have since been corroborated in America, where it was found that gipsy moth larvae may be carried twenty to thirty miles by the wind.*

One of the classical cases of the result of the dispersal of insects by normal causes is afforded by the Island of Krakatau, situated in the middle of the Sunda Straits between Java and Sumatra, which was completely sterilised of all life by a terrific volcanic outburst in August 1883. Krakatau, together with the neighbouring Verlaten and Lang Islands, which were equally sterilised, is situated at a distance of about 12 miles from the neighbouring and half-destroyed islands of Sebeki and Seboekoe, and about twice that distance from the nearest points of the Javan and Sumatran coasts. After the outburst the three islands were covered with pumice and layers of ash reaching on an average a depth of 100 ft., and frequently twice as deep, and assumed the appearance of a desert of the most desolate and uninhabited type. Within three years the flora had begun to re-establish itself and after another twenty years the islands were again covered with a mantle of green, the growth forming in places such luxuriant jungle that it was necessary to cut a way laboriously through it.† No insects were collected by the botanical expeditions that visited Krakatau in 1886 (33), 1897 (62), 1906 (137), the bracketed numbers against each year indicating the number of species of plants observed, and it was not until 1908 and 1921, 25 and 38 years respectively after its total destruction in 1883, that the insect fauna was collected by Jacobson and Dammerman. Their results are interesting and may be tabulated as follows :—

	1908.	1921.
Apterygota	1	2
Odonata.	1	4
Isoptera	2	2
Orthoptera	14	27
Thysanoptera	0	10
Rhynchota	15	74
Neuroptera	1	3
Coleoptera	23	115
Hymenoptera	51	66
Lepidoptera	10	84
Diptera	32	54
Total Insects	150	441
Total Animals	196	573

Such a result is extremely interesting and significant. Had we been ignorant of the effects of the eruption of 1883, an insect fauna of over four hundred species might have been regarded as quite a respectable number to find in one small island, whereas it has actually found its way there, across a gap of at least twelve miles of

* Collins, *Jl. Econ. Ent.*, x, pp. 170-176 (Feb. 1917).

† Ernst; *The new Flora of the Volcanic Island of Krakatau.* (Trans. ; 1908.)

sea, in less than forty years. I do not, however, propose to discuss the means of such dispersal, but merely emphasize the fact that dispersal does occur normally to a very considerable extent.

When an insect wanders outside of its normal habitat, such wandering is easily notable. As an instance, I may quote *Danaïs chrysippus*, a common Plains butterfly in India, which I have noticed at Kodaikanal (7,000 feet elevation, in the Palni Hills), and at Shillong (5,000 feet elevation, in the Khasi Hills); in neither locality is this butterfly able to breed, as its food-plant is absent, and the individuals seen were evidently stragglers from the plains below. At Kodaikanal also I noted a regular immigration from the plains below of *Papilio crithonius*, a common feeder on *Citrus*, but here again the butterfly would be unable to establish itself in the hills owing to the absence of the food-plant. In the plains *Polyommatus balticus* is often to be seen migrating against the wind towards the end of March, when large numbers have been bred out on the various peas grown during the cold weather; in this case available food-plants are widely distributed, and if the butterflies were not actually observed to be migrating, it would be difficult to say that they had done so.

Sometimes migration may be inferred from the sudden appearance in large numbers of the adult insects in localities where no particularly large occurrence of the earlier stages had been noted; as an instance of this I would refer to the sudden appearance of *Achaca janata*, L. (NOCTUIDAE) at Pusa on 11th July 1921. Thousands of individuals, in very fresh condition, suddenly invaded the district, hiding in the day-time in every bush and hedge, from which every blow dislodged them by dozens. This moth is a common pest of castor, but has a very wide range of food-plants. No exceptionally large numbers of the caterpillars had been noted, as would certainly have been the case had they bred locally, and I consider that this sudden outburst of the moths can only be ascribed to immigration. On 16th July the numbers of the moths were still noted as very large, and eggs were being laid thickly on castor leaves. Many moths were still about on 21st and 22nd July, by which date the young larvae were present on the castor, and were being eaten by crows.

The foregoing cases are examples of sporadic dispersal of individuals or of sporadic migration *en masse*, but we have also examples of more or less regular migration. I need not do more than refer to the case of migratory locusts, which normally breed in the desert areas in and around Baluchistan, and which invade India in swarms at irregular periods, occasionally penetrating as far south as Madras, and as far east as Sikkim.

Another case, which appears to be one of fairly regular seasonal migration, is afforded by *Pieris brassicae*, which feeds on cabbages in most cultivated areas along the south slopes of the Himalaya, from Kashmir to Sikkim, throughout the summer. At Pusa, which is situated at almost sea-level in the plains, roughly eighty miles south of the nearest considerable hills in Nepal, cabbages are grown only in the winter months, being usually sown about August, and the seedlings planted out in October, the plants remaining in the ground until April, when they are all dried up in the dry weather prevalent at that time of the year. At Pusa *Pieris brassicae* normally appears during the first week of February, in some years a few butterflies appearing on the wing then, in other years, large numbers. Thus, in 1916, I noted one male and one female on 28th January and another female on 30th January, whereas on 11th February 1914 and 24th February 1912 this butterfly suddenly appeared in large numbers. These butterflies lay eggs on the cabbages, the larvae maturing rapidly so that a cycle is passed through in about a month, and two or three broods occur until about the middle or end of April, when the cabbages are dried up and removed from the gardens. At this latter period the butterflies are still on the wing and are seen for a few days, but all disappear by the beginning of May. From May to January no sign of this butterfly in any stage is to be found, although the food-plant is available from about October onwards. The only

explanation that seems to fit the facts is that the first butterflies seen on the wing are immigrants, probably from the hills in Nepal, where the pupae have been hatched out by the returning warmth, and the butterflies, finding no suitable food in the hills at that time of year, invade the plains in search of nectar for the adults and food-plants for the larvae. The large quantity of mustard grown in the plains at that time of year may also help to attract them. This year (1925) the immigration seems to have failed entirely, and I have seen no *Pieris brassicae* in Pusa, and I have no notes of its occurrence for the last two or three years. This is interesting, because it may possibly be connected with a recent extension of the range of *Pieris brassicae* eastwards to the Khasi Hills in Assam. I collected at Shillong, in the Khasi Hills, for more or less extended periods during the years 1916-1920 inclusive without ever seeing *Pieris brassicae*, which is not an easily-overlooked insect. From 1921-1923 I did not visit Shillong, but on my return there in April 1924 *Pieris brassicae* was one of the first insects to be seen. It occurred in every garden on cabbages and was to be found in all stages throughout the summer; in the middle of November many larvae were pupating and presumably such pupae would hibernate, as the weather was then getting cold. It is very certain that *P. brassicae* found its way to Shillong for the first time between 1921 and 1923 and, finding conditions suitable, has now established itself there. Whether its first introduction to the Khasi Hills was the result of migration, there is no evidence to show, but it is very unlikely that this insect should have been introduced by human agency, as Shillong is an exporter, not an importer, of vegetables likely to carry eggs, and the casual introduction of an odd pupa or two would not be likely to establish a colony. *Pieris brassicae* is, of course, a very well-known migrant in Europe.

Another case of the annual outbreak of a crop-pest, in which we believe migration to be at work, is the case of *Agrotis ypsilon* on the *tal* lands at Mokameh, a station in Bihar on the south bank of the River Ganges. The lands in question comprise about forty square miles in all and lie south of Mokameh. The soil here is a stiff clay, and the whole of this land is inundated annually to a depth of from five to fifteen feet during the rainy season from June to September, about which month the water recedes concurrently with the fall in the Ganges. The land on the whole is flat, but some portions are higher than others, and these more elevated patches are usually exposed above water and ready for ploughing towards the end of September. Cultivation can be commenced about ten days after the water has receded from the land and can be continued for about fifteen days, after which the ground becomes so hard that it cannot be ploughed. Ploughing breaks the earth into lumps varying in size from that of a pea to that of a man's head. The fact that the land does not all dry simultaneously enables the sowing to be carried on for at least a month, although every year some land is necessarily left fallow owing to its hardening before it can be ploughed. After sowing, the land receives no further cultivation until harvest, the crops chiefly sown being *masur* (lentil, *Lens esculenta*) and *khesari* (*Lathyrus sativus*), with some peas on the higher lands. These lands, after having been under water for two or three months, are absolutely bare of vegetation when sown, although various small weeds spring up later. It is on these *tal* lands that the crops are attacked.

Apparently the newly-uncovered mud possesses some peculiar attraction (probably smell) for the female moths, and evidently they are so attracted and presumably lay their eggs on the mud, especially when it has been disturbed by ploughing, as the caterpillars are ready to attack the newly-sprouting crops, although the ground has previously been bare of vegetation. The first moths appear about the end of August, and the life-cycle of the autumn broods occupies about one month, so that broods of caterpillars in destructive numbers are soon built up. The insect is active in all stages throughout the cold weather, up to about the end of March, when the moths are very abundant at Pusa, although few are seen before that. In April very few

moths are to be obtained, and from May until about the middle of August no trace of the insect can be found in any stage. It might be supposed that the larvae or pupae aestivate during this period underground in the higher elevations which are not submerged during the rains, as it seems incredible that any stage could withstand complete continuous submersion under several feet of water for about three months on end. But, on the one hand, very detailed search has failed to reveal the presence of this insect in any stage during the summer months and, on the other hand, insectary experimental rearings of this moth have shown that there is no indication of any resting stage during this period, continuous broods succeeding one another from May to August, although the conditions during the dry weather and succeeding monsoon were evidently very unfavourable to this insect, and it proved to be very difficult to keep them alive at this time of the year.

We know that *Agrotis ypsilon* breeds freely in the hills during the summer. It is permissible to suppose, in the absence of direct proof, that the individuals which appear in the plains in the early autumn are migrants from the hills. Whether there is a return migration about April, we do not know. It is interesting to note that this same moth has recently been observed as a migrant in Egypt.

Other cases might be adduced, such as *Colias croceus fieldi*, which appears in the Plains in the cold weather only and is quite absent in the summer, when it occurs commonly in the Hills. But there is little use in compiling a long list of known or suspected migrants. The main object in this paper is to point out that, in the case of crop-pests, our anticipations of their occurrence may sometimes be set at naught by outbreaks that are not the result of abnormal local breeding, but of immigration from other localities, which may be at a considerable distance.

[*Note*.—After this paper had been written, I was interested to read in the newly-received *Journal of Economic Entomology* (xviii, p. 152, Feb. 1925) an article by E. P. Felt on "The Dissemination of Insects by Air Currents," in which he corroborates my idea, first put forward in 1910 (*Trans. Linn. Soc.* xiii, p. 322), of the importance of upper air currents in transporting insects long distances through the air.—T.B.F.]

A NEW PARASITE OF BUG EGGS (PROCTOTRYPIDAE).

By A. A. GIRAULT.

The following new species was reared from the eggs of a Pentatomid bug, *Tectocoris lineola*, F. (*banksi*, Don.), which attacks cotton. It occurred in company with *Hadronotus nigricornis*, Dodd, and was more abundant than that species.

***Hadronotus hirsutioculus*, sp. n.**

Runs to *nigricornis*, but the legs entirely black except knees and tarsi more or less and undersides of tibia 1; abdomen after 1 rugulose-striate longitudinally; distinct coarse longitudinal striae on distal scutum and scutellum; eyes densely, minutely hairy; face bounded by an arched carina above. In these five characters it differs from the species mentioned, but the vertex is also more rudely punctured and in the male the ocelli are differently placed, being in a curved line instead of in a triangle. In *nigricornis* the male ocelli are as in the female.

The male is similar, the 12-jointed antennae moniliform after the longer funicle 1.

Males, females, Ubobo, Queensland (*E. Ballard*).

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology, between 1st April and 30th June, 1925, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. E. A. ANDREWS :—1 Moth ; from Assam, India.

Dr. G. ARNOLD, Rhodesia Museum :—7 Coleoptera ; from Rhodesia.

Mr. T. V. RAMAKRISHNA AYYAR :—5 Lepidoptera ; from South India.

Mr. E. BALLARD :—9 Coleoptera, 14 Lepidoptera, and 18 Rhynchota ; from Queensland.

Dr. C. F. C. BEESON, Forest Entomologist :—35 Coleoptera ; from Dehra Dun, India.

Mr. L. E. W. BEVAN :—8 Chironomidae ; from Southern Rhodesia.

Mr. G. E. BODKIN, Government Entomologist :—9 Ticks ; from Palestine.

Dr. G. D. H. CARPENTER :—238 Coleoptera, 3 Hymenoptera, 10 Rhynchota, and 8 Orthoptera ; from Kenya Colony.

Mr. J. CLARK :—8 Coleoptera and 8 larvae ; from Western Australia.

DIRECTOR, COLONIAL INSTITUTE, AMSTERDAM :—12 Coleoptera ; from Dutch Guiana.

DIRECTOR, BOTANIC GARDENS, SINGAPORE :—13 species of Coccidae ; from Straits Settlements.

Mr. P. R. DUPONT : 1 species of Coccidae ; from Seychelles.

Mr. T. BAINBRIGGE FLETCHER, Imperial Entomologist :—8 Lepidoptera and 61 Odonata ; from India.

Lt. J. GHESQUIÈRE :—15 Coleoptera, 10 Parasitic Hymenoptera, 1 species of Coccidae, and 1 species of Aleurodidae ; from Belgian Congo.

Mr. F. D. GOLDING :—4 Hymenoptera ; from Southern Nigeria.

Col. F. W. HALLOWES :—2 Coleoptera, 26 Formicidae, 2 species of Coccidae, and 1 species of Aphidae ; from Kenya Colony.

Mr. G. L. R. HANCOCK :—2 Tabanidae, 5 other Diptera, 25 Coleoptera, 7 Hymenoptera, 21 Lepidoptera, and 218 Rhynchota ; from Uganda.

Mr. E. HARGREAVES, Government Entomologist :—3 Nycteribiidae, 92 Culicidae, 21 Tabanidae, 2 *Glossina*, 43 other Diptera, 205 Coleoptera, 28 Hymenoptera, 39 Lepidoptera, 24 species of Coccidae, 171 other Rhynchota, 49 Orthoptera, 9 Planipennia, 14 Trichoptera, 100 Collembola, and 50 Mites ; from Sierra Leone.

Mr. G. M. HENRY, Colombo Museum :—540 Coleoptera, 30 Planipennia, and 2 Embiididae ; from Ceylon.

Mr. G. V. HUDSON :—10 Diptera, 141 Coleoptera, and 2 Ichneumonidae ; from New Zealand.

Mr. M. AFZAL HUSAIN, Government Entomologist :—3 Parasitic Hymenoptera ; from Punjab, India.

Dr. A. INGRAM :—4 Siphonaptera ; from South Africa.

INSPECTOR-GENERAL OF AGRICULTURE, BAGHDAD :—5 Coleoptera, 25 Parasitic Hymenoptera, 3 Lepidoptera, 14 Rhynchota, and 2 Orthoptera ; from Iraq.

Mr. E. JACOBSON :—175 Coleoptera ; from Sumatra.

Mr. L. G. E. KALSHOVEN, Forest Entomologist :—151 Coleoptera ; from Dutch East Indies.

Mr. C. BODEN KLOSS :—235 Orthoptera ; from Mentawai Islands.

Mr. W. R. S. LADELL :—5 Orthoptera ; from Siam.

Mr. S. LEEFMANS :—10 Lepidoptera ; from Java.

Dr. LI. LLOYD.—12 Diptera, 26 Coleoptera, 77 Hymenoptera, 135 Lepidoptera, 5 Rhynchota, 123 Orthoptera, 17 Odonata, and 4 Planipennia ; from Northern Nigeria.

Mr. N. C. E. MILLER :—10 Rhynchota and 3 Orthoptera ; from Tanganyika Territory.

MINISTRY OF AGRICULTURE, CAIRO :—16 Orthoptera ; from Egypt.

Mr. H. K. MUNRO :—34 Diptera ; from South Africa.

MUSEUM D'HISTOIRE NATURELLE, GENEVA :—256 Orthoptera ; from Asia.

NATAL MUSEUM, PIETERMARITZBURG :—58 Rhynchota ; from South Africa.

NATIONAL MUSEUM, MELBOURNE :—60 Rhynchota ; from Australia.

Prof. G. H. F. NUTTALL, F.R.S. :—80 Parasitic Hymenoptera ; from Java.

Prof. R. P. O. PEIL :—49 Hymenoptera ; from China.

Mr. Y. RAMACHANDRA RAO :—12 Coleoptera ; from South India.

Dr. J. R. RISQUEZ :—1 Reduviid bug ; from Venezuela.

Mr. A. H. RITCHIE, Government Entomologist :—70 Coleoptera, 19 Rhynchota, and 12 Oithoptera ; from Tanganyika Territory.

Mr. H. W. SIMMONDS :—2 Lepidopterous larvae parasitised by worms ; from Federated Malay States.

Prof. Y. SJÖSTEDT :—79 Coleoptera and 7 Isoptera ; from various localities.

Mr. H. J. SNELL :—2 Culicidae, 212 other Diptera, 28 Coleoptera, 212 Hymenoptera, 144 Rhynchota, 10 Orthoptera, 13 Planipennia, 8 Odonata, and 2 Spiders ; from Zanzibar.

Mr. E. R. SPEYER :—104 Diptera and 21 early stages, 17 Coleoptera, 2 Lepidoptera, 23 Rhynchota, 11 Collembola, 10 Mites, 2 Millipedes, and 7 Woodlice ; from Cheshunt, Herts.

Mr. H. P. THOMASSET :—10 Culicidae, 192 other Diptera, 181 Coleoptera, 87 Hymenoptera, 65 Lepidoptera, 149 Rhynchota, 82 Orthoptera, 2 Chrysopidae, and 2 Trichoptera ; from Natal.

Mr. F. W. URICH :—18 Culicidae, 10 *Tabanus*, 45 other Diptera, 75 Coleoptera, 21 Hymenoptera, 14 Lepidoptera, 31 Rhynchota, and 11 Orthoptera ; from San Thomé.

Mr. R. VEITCH :—3 *Simulium*, 20 Agromyzidae, 6 Coleoptera, and 11 Lepidoptera ; from Fiji Islands.

WELLCOME TROPICAL RESEARCH LABORATORIES :—5 *Tabanus* and 3 early stages, 3 Hippoboscidae, 11 other Diptera and 4 larvae, 131 Coleoptera, 12 Parasitic Hymenoptera, 9 Lepidoptera, 70 Thysanoptera, 2 species of Coccidae, 213 other Rhynchota, and 32 Orthoptera ; from British Sudan.

Mr. D. S. WILKINSON, Government Entomologist :—20 Diptera, 136 Coleoptera, 29 Parasitic Hymenoptera, 20 Lepidoptera, 4 species of Aphidae, and 98 Ticks ; from Cyprus.

Mr. H. WILKINSON :—417 Coleoptera, 6 Parasitic Hymenoptera, 258 Lepidoptera, 5 species of Coccidae, and 6 Trichoptera ; from Kenya Colony.

Mr. G. N. WOLCOTT :—16 Coleoptera ; from Haiti.

ZOOLOGICAL MUSEUM, LENINGRAD :—38 Trichoptera ; from Russia : and 1,408 Orthoptera ; from Asia.

PHYSICAL FACTORS IN MOSQUITO ECOLOGY.

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(Research undertaken with a Government Grant from the Royal Society.)

	CONTENTS.	PAGE
I.	Introductory	187
II.	Methods of investigation	189
III.	Hydrogen-ion toleration limits	191
IV.	Solute-concentration limits	194
V.	Dissolved oxygen requirements	196
VI.	Saline ammonia toleration limits	198
VII.	The toleration-limits of the various species	199
VIII.	Algal distribution and the food of larvae	218
IX.	Causes of larval mortality	229
X.	The detailed study of some typical water-bodies	234
XI.	On the possibility of biological control	241
XII.	Summary and conclusions	245
XIII.	Literature cited	246

I.—Introductory.

Over a quarter of a century has now elapsed since the genius of Ross convicted mosquitos of responsibility for the spread of malaria, but the factors involved in the distribution of the insects in Nature are hardly better understood to-day—when, in addition to filariasis and malaria, they have been inculpated in respect of the transmission of at least two other major diseases—than they were at the time of the original discovery of August 1897.

All that was known up to the end of 1921 has been ably summarised by Lamborn (1922) and amounts to this, that, for quite unexplained reasons, certain species of Anophelines are to be found under certain not exactly definable but none the less clearly perceptible conditions of water. This is mainly the work of Strickland and Hacker (1920), and it is noteworthy that to these and the other Malayan workers is due much the largest portion of our knowledge of mosquito ecology. Research in other countries has nearly all been along different lines. The author (Senior-White, 1921), in ignorance of Hacker's work, almost simultaneously evolved the system of "association units," but extended the study of this point to mosquitos other than Anophelines. About the same time Iyengar (1919) published the results of a survey in which, in broad terms, reference was made to qualities of water and to plant-associations in connection with Anopheline distribution; and a little later Wesenburg-Lund (1921) issued an elaborate monograph on the North European species of mosquitos, showing that throughout the seasons these came and went in a regular succession, and that each species favoured special habitats; but he brought the problem of the reasons for this no nearer solution, although he alone, at that time, of the various workers could have been familiar with the work of Sørensen, under the same Carlsberg Fund, that was later to furnish the first line of definite attack on the problem. Lamborn, in his summary, makes no reference to the work of Iyengar and Wesenburg-Lund.

Though it arrives at no definite conclusions, Lamborn's paper is a most valuable record of experiments and observations all tending to show how utterly uncomprehended the underlying factors of mosquito distribution have been. For the first time water analyses, albeit incomplete and not covering the constituents usually investigated by workers on hydrobiology, were given with reference to mosquitos; but the discussion of the details of this paper can more profitably be deferred to a

later section. However, at the end of it the problem still remained in the state graphically summed up by Watson (1921) in his preface, ". . . in a single ravine, the various insect inhabitants may come and go in the wondrous fashion of a fairy tale."

Just before the appearance in print of Lamborn's paper there had been published the first attempt to take a new line with the problem. The credit for this lies with MacGregor (1921), who then set out the preliminary results of his work on the effects of hydrogen-ion concentration on larvae. The basic researches of Sørensen were shown to be applicable to yet another biological problem.

When he published, MacGregor seems to have made only a few observations. All he was able to show was that, for British species, the tree-hole breeders favoured an acid reaction, the stream-breeders an alkaline, and that in the wrong concentration both sets were attacked by a fungus.

Thereafter, Buxton (1924) made a few observations in Palestine, but he also contributed little to the elucidation of the relationship between mosquitos and pH. A second publication by MacGregor (1924) on the fauna of Mauritius makes a few more generalisations on the subject, but so far no one seems to have made a serious investigation of hydrogen-ion concentration in relation to mosquito bionomics.

The writer commenced the study of this problem early in 1923, working on the mosquito fauna of Ceylon. From that time observations have been steadily accumulated, so that the conclusions reached in the paper now offered are based on a total of seven hundred observations. As much attention has been paid to water in which mosquitos were not found as to water in which they were present, but it has not been found possible to make a comparative study of a non-malarious locality, as urged by Watson (1921, p. 216).

At first it seemed as if the key had been discovered, as would also appear to have been the earlier impressions of MacGregor and Buxton. Waters from which larvae were absent were generally found to be of exceptional pH values, and the limits of the individual species seemed as if they were going to be easily ascertainable. But with increasing accumulation of results, more and more exceptions have declared themselves; the toleration range of many species has been found to extend considerably beyond the points where, at the earlier stage of the work, their limits were thought to lie, and, conversely, larvae were frequently found absent from waters which appeared suitable for them in this and every other respect, whilst they would disappear from pieces of water in which they had recently existed and return to it without any change in pH. The work on hydrogen-ion concentration had therefore to be supplemented by the investigation of other factors.

Before turning to the actual work it is pleasant to record and acknowledge the large amount of help which has been received from other workers. The investigation being in large part along lines other than entomological, without help from workers in Botany and Biochemistry it could not have been successfully carried out.

My thanks are chiefly due to Dr. W. R. G. Atkins, F. R. S., Head of the Department of General Physiology at the Marine Biological Laboratory, Plymouth, to whom I am indebted for constant help and advice; to Miss Rich, working in Prof. Fritsch's laboratory, for many of the determinations of Algae; to Prof. N. G. Ball, University College, Ceylon, for further help in regard to Algae; to Mr. Petch, Mycologist to the Ceylon Department of Agriculture, for determinations of Phanerogams and Fungi and for affording me access to the library of his Department; to Mr. F. W. Edwards, of the Natural History Museum, for confirming the identification of one or two of the rarer and more difficult mosquitos encountered; and finally to Sir Ronald Ross, who, with Col. S. P. James, Malaria Adviser to the Ministry of Health, not only recommended me for the Royal Society Grant which enabled some of the more expensive apparatus to be purchased, but also took an encouraging interest in the progress of the work.

II.—Methods of Investigation.

Whilst on leave towards the end of 1923 I discussed with Dr. Atkins the failure of pH to explain as much as was hoped, and it was decided that on my return to the East, in addition to hydrogen-ion concentration, there should also be measured the relative proportions of total solids in solution, and the oxygen and ammonia contents of the water.

Throughout this investigation, pH has been measured colorimetrically, by means of Clark and Lubs' indicators. In dealing with the often brownish water of tree-holes and bamboos great accuracy is not attainable, but, even in extreme cases, accuracy to pH 0.2 is usually possible by adding single drops of indicator to very small quantities of water on a white tile. Previous workers have referred to their difficulty in taking round the field a set of standard buffer-solution tubes, but sufficient accuracy is obtainable by comparison of the water under examination plus indicator with the coloured plates given by Clark (1920), which can be purchased separately from the book for use in the field. By this means it is quite easy to work to 0.1, although in tabulating results steps of 0.2 have been used. All results have been checked by testing the sample with two indicators, and if there has been a difference in value, as occasionally happens, the mean of the two readings has been recorded.

In any work in the tropics it is almost invariably found that difficulties which were not experienced by the originators of the method in cooler climates are encountered. The colorimetric determination of pH is no exception. In solutions as diluted for use, except of course in the alcoholic methyl-red, fungus growth is frequent, and the CO_2 thus evolved may render the solution so acid that its virage is obscured, at least in the lower part of its range. Even toluene, unless very frequently renewed, will not obviate this, and if shaking will not restore the solution to approximately the mid-point of its range, this must be effected by the addition of a drop or two of alkali, unless the solution is to be thrown away and a fresh lot made up from stock.

Total solids in solution have been measured proportionately by electrical conductivity, using a Kohlrausch bridge reading direct in ohms, and a Hamburger cell, calibrated by testing with N/100 KCl. The constant of the cell used here has only varied from 0.996 to 1.14 at various determinations. As Atkins & Harris (1924) show, conductivity is proportional to total solids over a wider range than is met with in most fresh-water biological work. All conductivity measurements have been carried out at a temperature of 25° C., which in a field laboratory in the Tropics far from an ice supply is an easier temperature to maintain constant than is 0° C., as used by Atkins.

Oxygen in solution has been measured by Winkler's method. The sodium thio-sulphate used in the final titration not being very stable in an atmosphere of high temperature and humidity, it was brought out from England in serum ampoules made up for me by British Drug Houses, Ltd., in quantities sufficient to make up a litre of N/40 solution in each ampoule, which could be broken under water without possibility of loss. If the standard solution was more than three days old, it has been invariably necessary to titrate it prior to use against standard iodine in the usual way.

Here again, with a very hard water, such as is commonly encountered in this Island, an unexpected difficulty has appeared, in that the manganous hydroxide precipitated has refused, in acid waters, to turn to the brown manganic salt, save very slowly, and sometimes not at all, even after standing for three weeks at this stage. Sunlight accelerates the change somewhat. Preliminary shaking with air shows that this refusal to react is a CO_2 effect only, but in such cases it has been impossible to follow Winkler's directions for procedure and acidify the manganic and not the manganous salt. However, I do not think, given that the next stage in the process is not hurried, that the accuracy of the method is greatly impaired. So far as possible, the precipitate has been allowed to stand a week before taking the process further.

Ammonia has been estimated by direct Nesslerisation, using the U.S.A. Public Health Association (1920) method for precipitating the magnesium and calcium hydroxides before adding the reagent. This, of course, gives a measurement of saline ammonia only. The much more important estimation of the albuminoid ammonia has not so far been possible, owing to the lack of the necessary apparatus.

TABLE
Hydrogen-ion¹

[The first figure in each column is the number

Species.	pH	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.6
<i>Anopheles aitheni</i> ...		—	—	—	—	—	—	—	1 4	—	—	1 1	1
„ <i>barbivros</i> ...		—	—	—	—	—	—	—	1 1	—	1 4	8 7	3 1
„ <i>stnensis</i> ...		—	—	—	—	—	—	—	—	—	—	—	2
„ <i>gigas</i> ...		—	—	—	—	—	—	—	—	1 6	—	—	—
„ <i>fuliginosus</i> ...		—	—	—	—	—	—	—	—	—	2 2	—	—
„ <i>jamesi</i> ...		—	—	—	—	—	—	—	—	—	—	1 1	2
„ <i>tessellatus</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
„ <i>listoni</i> ...		—	—	—	—	—	—	—	—	4 18	7 18	13 43	—
„ <i>maculatus</i> ...		—	—	—	—	—	—	2 9	1 4	3 10	7 51	9 38	—
„ <i>karwari</i> ...		—	—	—	—	—	—	1 1	—	—	—	—	—
„ <i>leucosphyrus</i> ...		—	—	—	—	—	—	—	1 1	—	—	—	—
„ <i>vagus</i> ...		—	—	—	—	—	—	—	—	—	1 1	—	—
<i>Megarhinus splendens</i> ...		—	—	—	—	—	—	—	—	—	—	2 2	—
<i>Uranotaenia campestris</i> ...		—	—	—	—	—	—	—	1 1	—	1 2	7 65	4 50
<i>Rachionotomyia aranoioides</i> ...		1 13	—	1 3	—	—	—	2 10	—	—	1 1	—	2 15
<i>Armigeres aureolineatus</i> ...		—	—	—	—	—	—	1 1	—	—	—	—	—
„ <i>obturans</i> ...		2 33	—	—	—	—	—	2 28	1 1	—	—	—	4 7
<i>Stegomyia sugens</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
„ <i>albopicta</i> ...		1 1	—	1 1	—	—	1 9	2 17	—	1 1	2 5	2 28	7 72
<i>Finlaya macdougalli</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
„ <i>pseudotaeniata</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
„ <i>trilineata</i> ...		—	—	—	—	—	—	—	—	—	—	1 1	2
„ <i>gubernatoris</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
„ <i>greeni</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
<i>Aedes pseudomedioscissatus</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
„ <i>longirostris</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
<i>Ficalbia luxonensis</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
<i>Orthopodomyia anopheloides</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
<i>Lutzia fuscana</i> ...		—	—	—	—	—	—	—	—	—	—	2 10	—
<i>Culex bitaeniorhynchus</i> ...		—	—	—	—	—	—	—	—	1 5	1 20	6 85	—
„ <i>whitmorei</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
„ <i>mimulus</i> ...		—	—	—	—	—	—	—	—	—	2 3	4 21	—
„ <i>tritaeniorhynchus</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
„ <i>sitiens</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
„ <i>vishnui</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
„ <i>barraudi</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
„ <i>fatigans</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
„ <i>fuscoccephalus</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
„ <i>brevipalpis</i> ...		—	—	—	—	—	—	—	—	—	—	2 4	—
„ <i>castrensis</i> ...		—	—	—	—	—	—	—	—	—	1 2	1 20	—
„ <i>bahri</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
„ <i>fragilis</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
„ <i>pallidothorax</i> ...		—	—	—	—	—	—	—	—	—	—	1 91	—
„ <i>minutissimus</i> ...		—	—	—	—	—	—	—	—	—	9 41	5 38	—
„ <i>uniformis</i> ...		—	—	—	—	—	—	—	—	1 3	—	1 1	—
„ <i>minor</i> ...		—	—	—	—	—	—	—	—	—	—	—	—
<i>Dixa zeylanica</i> ...		—	—	—	—	—	—	—	—	1 1	—	—	1
		4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.6

III. Hydrogen-Ion Toleration Limits.

The number of times each species has been found at each concentration, and the total number of larvae obtained at such value, is shown in Table I. In Ceylon, natural waters, as distinguished from artificial collections in bamboos, tree-holes, old tins, etc., have been found to extend from pH 5.4 to 9.2, and values beyond these

I.

Records.

of times, the second the total larvae, found.]

	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8
2	42	31	1	—	1	11	2	—	—	—	—	—	—	—	—	—
9	518	186	162	32	38	261	1	—	—	2	21	—	—	—	—	—
5	117	177	162	7	—	—	—	1	2	2	5	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	2	1	1	—	—	—	—	—	—	1	15	—	—	—	—	—
1	11	51	11	1	—	2	2	—	—	1	4	—	—	—	—	—
—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19	6424	11417	527	3713	527	231	21	8	—	1	1	—	—	—	—	—
21	7025	20614	412	62	74	101	1	—	—	2	2	—	—	—	1	4
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4	191	17	294	321	52	25	—	—	—	—	—	—	—	—	—	—
—	1	12	31	5	—	—	—	—	—	—	—	—	—	—	—	—
6	913	423	43	161	11	1	—	—	—	1	1	—	—	—	—	—
4	103	133	71	9	—	1	21	26	—	—	—	—	—	—	—	—
7	4	—	—	—	3	1261	4	—	1	51	4	—	—	—	—	—
1	1502	3144	1391	533	1065	1371	336	1111	259	—	—	—	—	—	—	—
1	101	23	47	—	1	17	—	1	1	—	21	4	—	—	1	1
11	4512	7212	214	1812	406	1324	374	451	1	—	—	—	2	121	1	6
—	—	—	1	50	—	—	1	4	—	1	42	6	—	—	2	8
1	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
—	1	21	2	—	1	11	2	—	—	—	—	—	—	—	—	—
1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3	4	—	—	1	71	1	—	—	1	1	—	—	—	—	—	—
2	21	161	1	—	—	—	—	—	—	—	—	—	—	—	—	—
1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	1	2	—	—	—	—	—	—	—	—	—	—	—
5	83	71	1	—	—	—	1	1	—	1	1	—	—	—	—	—
7	5010	655	201	12	7	—	1	3	—	—	—	—	—	—	—	—
2	151	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—
3	5	—	1	12	8	2	3	—	—	1	8	—	—	—	—	—
3	51	32	4	—	—	—	—	—	—	1	6	—	—	—	—	—
—	—	—	—	—	—	—	1	20	—	—	—	—	—	—	—	—
7	312	61	31	21	11	11	5	—	—	2	3	—	—	—	—	—
1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3	44	273	13	—	—	1	2	—	1	222	221	—	—	—	1	12
1	1	—	1	241	2	—	—	—	—	—	—	—	—	—	—	—
2	31	11	12	—	1	63	4	—	—	—	—	—	—	—	—	—
—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—
1	13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	41	11	3	—	—	—	—	—	—	—	—	—	—	—	—	—
10	3110	333	73	95	122	9	—	—	—	—	—	—	—	—	—	—
4	212	82	191	11	24	46	—	1	1	—	—	1	2	—	—	—
3	8	—	—	—	1	5	—	—	—	—	—	—	—	—	—	—
4	236	103	131	1	—	1	1	—	—	—	—	—	—	—	—	—
6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	

points on either side have only occurred in artificial collections as above. But it is apparent that natural-water mosquitos will not tolerate concentrations up to the extremes that occur, that 5.8 on one side and 8.6 on the other set the limits to distribution, and that, generally, the morphologically less-specialised species have the widest range. This means, unfortunately, that the Anophelines, speaking broadly, have a wider toleration limit than the Culicines. Even so, a study of the table shows that very many more data are required on nearly every species of the forty-seven now listed before definite assertions as to limits can be safely made.

It is less easy to generalise about the artificial-water breeders. Such waters are of very diverse nature. It is a far cry from a coconut shell in deep shade containing fermenting rice and reeking of acetic acid, at pH 4.4, to a water-butt in full sunlight, its contents green with algae, at 9.6+, but both are "artificial" water, and contain species not to be found in "natural" waters, though in all other respects the biological conditions of the two receptacles are as the poles apart. The commonest of the artificial water breeders, *Stegomyia albopicta*, is shown to tolerate water right through the entire pH range found. Whether even this species none the less has pH preferences is a matter that will be returned to in a subsequent section.

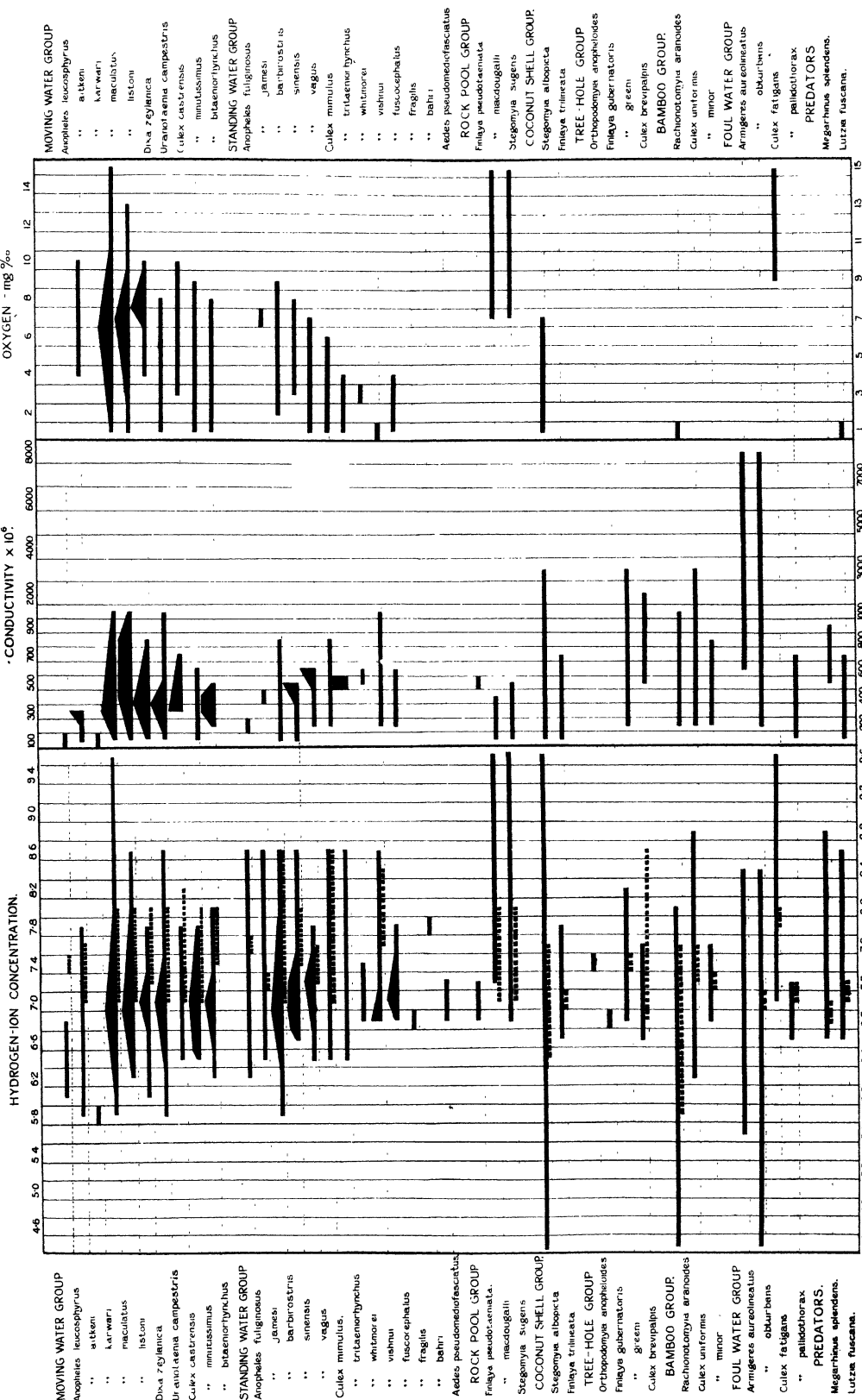
Another point is that it is possible that the same species in different localities may have different limits; in other words, that there may be biological races that are morphologically identical. MacGregor (1924) in Mauritius was dealing with a fauna containing three species also found in Ceylon. He states that in his experience the commoner Culicines are acidophiles, though *C. fatigans* will exceptionally tolerate alkalinity also. His definition "commoner" probably covers all the three species found in both countries. In regard to *fatigans*, my few records show none on the acid side of neutrality at all. The second species common to both islands, *C. tritaeniorhynchus*, appears in Ceylon to have narrow limits on both sides of neutrality; whilst of the third, *C. sitiens*, I have practically no personal experience, but being a brackish-water breeder, it is very unlikely that it would occur in acid water, the pH of pure sea-water in the Tropics being about 8.4. MacGregor has informed me (*in litt.*) that the statement in his paper that 7.8 is the neutral point is a printer's error only. The possibility of there being similar biological races in another respect is referred to in the next Section. Only investigations carried out by numerous observers in different areas where there is a similar fauna can elucidate this point, which is one of the reasons for writing up the results of my work at this admittedly incomplete stage in the investigation. It would be extremely valuable, for instance, to have records of toleration limits of the same Oriental species on the acid Bhils of Sylhet to compare with results on the magnesium-limestone hills of Ceylon, the two areas containing many identical species with Malayan affinities.

In Sections V, VII, and VIII many instances will be given in which the pH value is shown to be of two components, that due to gases and that due to more stable solutes. CO_2 in solution forms bicarbonates, but oxygen only appears to affect the concentration when present in excess of the saturation value. The two gases, of course, act in opposite directions, tending to acidity and alkalinity respectively, though oxygen in solution is without effect on the reaction.

If the water under examination be shaken in a hard glass (*e.g.*, a cordite) tube with excess of air the free carbonic acid in solution is largely removed, whilst excess of oxygen is also expelled.* The pH value rises or falls according to which gas has been in excess, and the final value represents the pH due to non-volatile solutes.

* This process is most conveniently carried out on the already indicated sample. The tube should be laid on its side to remove as much CO_2 as possible at the end of the shaking, which should be repeated at least three times, or until no further change occurs. Brom-thymol-blue froths in this process, and loses depth of tint. Extra indicator must be added to counteract this before the final shaking. Usually another drop per cc. is required. The other indicators neither froth nor lose depth of tint. Water at pH 8.4 or over will absorb CO_2 from the air when shaken. Such water is usually alkaline on account of the photosynthesis of algae removing the CO_2 .

Figure 1 is a composite graph showing the relationship between hydrogen-ion concentration (pH) and oxygen concentration (mg %) for various mosquito species and groups. The graph is divided into three main sections: MOVING WATER GROUP, STANDING WATER GROUP, and FOUL WATER GROUP. Each section contains multiple sub-graphs for different species or groups, showing the distribution of oxygen concentration across a range of pH values. The x-axis represents pH (4.5 to 14), and the y-axis represents oxygen concentration (mg %) (0 to 14). The data is presented as a series of horizontal bars and lines, indicating the range of oxygen concentrations for each species or group at different pH levels.



The necessity for thoroughly investigating CO_2 pressure was not appreciated in time for the work to be complete enough for publication in the present paper, and even the residual pH values are founded on too few figures to dogmatise, but it would appear that the total range is of much less extent than that found naturally, as will be seen from Table II, from which it also appears that non-volatile acidity is not tolerated by any species of the two "natural water" groups, but only by "artificial water" breeders. Figures are too few for particularisation in regard to individual species, but I think the results clearly indicate that in "natural water" pH dissolved gases play a far larger part than do salts of a more stable nature. The latter are likely to vary with the geological formation of the country of the investigation, and it is

TABLE II.

"Residual" Hydrogen-ion Records.

[The first figure in each column is the number of times, the second the total larvae, found.]

Species.	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6
<i>Anopheles aitheni</i> ...	—	—	—	—	—	—	1	11	11	31	1	—	—	—	—
„ <i>barbivostri</i> ...	—	—	—	—	—	—	1	11	2	—	2	24	2	32	20
„ <i>sinensis</i> ...	—	—	—	—	—	—	—	—	1	21	23	61	6	—	—
„ <i>fuliginosus</i> ...	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—
„ <i>jamesi</i> ...	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—
„ <i>listoni</i> ...	—	—	—	—	—	—	3	5	—	5	96	214	5	—	—
„ <i>maculatus</i> ...	—	—	—	—	—	—	3	246	536	205	206	155	19	—	—
„ <i>leucosphyrus</i> ...	—	—	—	—	—	—	—	1	2	—	—	—	—	—	—
„ <i>vagus</i> ...	—	—	—	—	—	—	—	1	1	—	1	13	—	—	—
<i>Megarhinus splendens</i> ...	—	—	—	—	—	2	2	1	—	—	—	—	—	—	—
<i>Uranotaenia campestris</i> ...	—	—	—	—	—	—	1	23	14	—	1	1	—	—	—
<i>Rachionotomyia aranoioides</i> ...	1	9	—	1	1	1	1	1	—	1	1	—	—	—	—
<i>Armigeres obturbans</i> ...	—	—	—	—	—	—	1	314	—	—	—	—	—	—	—
<i>Stegomyia sugens</i> ...	—	—	—	—	—	—	1	71	19	—	—	2	61	1	—
„ <i>albopicta</i> ...	—	—	—	1	12	—	2	20	2	55	1	51	24	74	—
<i>Finlaya macdougalli</i> ...	—	—	—	—	—	—	1	50	—	—	—	2	62	8	—
„ <i>trilineata</i> ...	—	—	—	—	—	—	1	2	—	—	—	—	—	—	—
„ <i>gracilis</i> ...	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—
<i>Aedes longirostris</i> ...	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—
<i>Lutzia fuscana</i> ...	—	—	—	—	—	—	1	21	2	—	—	—	—	—	—
<i>Culex bitaeniorhynchus</i> ...	—	—	—	—	—	—	—	—	2	42	32	121	3	—	—
„ <i>mimulus</i> ...	—	—	—	—	—	—	1	1	—	—	1	5	—	1	2
„ <i>sitiens</i> ...	—	—	—	—	—	—	—	—	—	—	—	—	—	1	20
„ <i>vishnui</i> ...	—	—	—	—	—	—	—	—	—	1	3	—	1	1	5
„ <i>barraudi</i> ...	—	—	—	—	—	—	—	—	—	1	2	—	—	—	—
„ <i>fatigans</i> ...	—	—	—	—	—	—	—	—	—	—	2	43	2	212	—
„ <i>brevipalpis</i> ...	—	—	—	—	—	1	3	—	1	1	—	—	—	—	1
„ <i>castrensis</i> ...	—	—	—	—	—	—	1	21	20	—	2	13	—	1	2
„ <i>pallidothorax</i> ...	—	—	—	—	—	—	1	12	4	—	—	—	—	—	—
„ <i>minutissimus</i> ...	—	—	—	—	—	—	1	12	14	1	11	13	61	1	—
„ <i>uniformis</i> ...	—	—	—	—	—	—	—	1	1	1	12	18	—	—	—
„ <i>minor</i> ...	—	—	—	—	—	—	—	1	4	—	—	—	—	—	—
<i>Dixa zeylanica</i> ...	—	—	—	—	—	—	—	1	17	30	2	123	42	2	—

possible that this "residual" pH value will be found to be very different in its average position on the Sørensen scale in various countries. This may explain the apparently contradictory values for toleration limits for the same species when such are investigated in various parts of its range.

In figure 1, where the "residual" range is shown beneath the diagram of "natural" range for each species on which data for the former are available, the overlap at each end of the latter indicates regions in which pH must be gas-caused to be tolerated; but before allowing much weight to this point the number of observations from which the "residual" pH line is drawn should be looked up in Table II.

IV. Solute-Concentration Limits.

These are summarised, in terms of conductivity $\times 10^6$, in Table III. This work has only been carried on for half the time that pH work has been done, thus the number of observations and the value of generalisations drawn therefrom are correspondingly reduced. Natural waters, as defined in the previous section, have been found varying between the limits of 62 and 922; in the first instance in a spring arising in the bed of a stream cut down to laterite sub-soil, in the second instance in a stream descending from highly manured land under rubber. Here again we find the two commonest *Anophelines* and *Uranotaenia*, an unspecialised genus, with the widest toleration limits, whilst the genus *Culex* appears to be much more restricted in its requirements. Turning to artificial water, we find the breeders therein with much wider toleration limits, up to 3,000, with one genus, *Armigeres*, extending to a toleration of very high concentrations. There is, however, in this group an essential

TABLE

Conductivity

[The first figure in each column is the number

Species.	0/ 99	100/ 199	200/ 299	300/ 399	400/ 499	500/ 599	600/ 699	700/ 799	800/ 899	900/ 999	1000/ 1199	1200/ 1399	1400/ 1599
<i>Anopheles aitheni</i> ...	1	4	—	5	8	—	—	—	—	—	—	—	—
„ <i>barbivros</i> ...	1	12	22	32	183	41	11	191	23	—	—	—	—
„ <i>sinensis</i> ...	1	41	2	—	4	97	18	—	—	—	—	—	—
„ <i>fuliginosus</i> ...	—	1	1	—	—	—	—	—	—	—	—	—	—
„ <i>jamesi</i> ...	—	—	—	1	1	—	—	—	—	—	—	—	—
„ <i>listoni</i> ...	1	34	187	40	10	375	212	2	8	172	131	8	—
„ <i>maculatus</i> ...	5	514	816	8	244	81	111	13	32	331	6	—	—
„ <i>karwari</i> ...	1	1	—	—	—	—	—	—	—	—	—	—	—
„ <i>leucosphyrus</i> ...	2	3	—	—	—	—	—	—	—	—	—	—	—
„ <i>vagus</i> ...	—	1	9	—	1	253	254	7	—	—	—	—	—
<i>Megarhinus splendens</i> ...	—	—	—	—	1	1	—	1	—	2	3	—	—
<i>Uranotaenia campestris</i> ...	3	31	23	151	11	1	—	2	21	61	3	—	—
<i>Rachionotomyia</i>													
<i>aranoides</i> ...	—	2	32	82	231	5	—	2	2	21	1	—	—
<i>Armigeres aureolineatus</i> ...	—	—	—	—	—	1	451	3	—	1	1	2	84
„ <i>obturans</i> ...	—	1	101	31	1	512	121	403	350	1	16	2	77
<i>Stegomyia sguens</i> ...	1	71	191	17	—	1	21	—	—	—	—	—	—
„ <i>albopicta</i> ...	1	476	375	885	194	100	—	5	193	83	255	15	1
<i>Finlaya macdougalli</i> ...	2	54	—	1	4	—	—	—	—	—	—	—	—
„ <i>pseudotaeniata</i> ...	—	—	—	—	1	1	—	—	—	—	—	—	—
„ <i>trilineata</i> ...	1	22	4	—	1	2	—	1	1	—	—	—	—
„ <i>greeni</i> ...	—	1	22	2	—	—	—	1	1	—	—	—	—
<i>Lutzia fuscana</i> ...	1	2	—	1	8	—	3	61	11	2	—	—	—
<i>Culex bitaeniorhynchus</i> ...	—	3	71	35	113	4	—	—	—	—	—	—	—
„ <i>whitmorei</i> ...	—	—	—	—	1	11	1	—	—	—	—	—	—
„ <i>mimulus</i> ...	—	1	22	31	81	23	61	21	5	—	—	—	—
„ <i>tritaeniorhynchus</i> ...	—	—	—	—	4	11	—	—	—	—	—	—	—
„ <i>vishnui</i> ...	—	1	1	—	2	31	2	—	1	3	—	—	—
„ <i>barraudi</i> ...	—	—	—	—	—	—	—	1	2	—	—	—	—
„ <i>fuscocephalus</i> ...	—	1	2	—	1	112	2	—	—	—	—	—	—
„ <i>brevipalpis</i> ...	—	—	—	—	2	4	—	1	1	—	—	—	—
„ <i>castrensis</i> ...	—	—	4	35	—	—	1	11	2	—	—	—	—
„ <i>pallidothorax</i> ...	1	11	31	91	—	—	—	1	1	—	—	—	—
„ <i>minutissimus</i> ...	1	92	45	154	101	31	1	—	—	—	—	—	—
„ <i>uniformis</i> ...	—	3	191	1	—	4	32	—	2	15	—	7	—
„ <i>minor</i> ...	—	1	22	9	—	—	—	—	1	2	—	—	—
<i>Dixa zeylanica</i> ...	1	1	—	7	206	25	—	—	2	3	—	—	—

difference between the solutes causing the conductivity that the method does not reveal. In natural waters such are mainly mineral salts, whereas in artificial collections of water they must be almost entirely of an organic nature ; for the original source of all such waters is rain, which, taken after it had been falling heavily for some hours, I have found to have a conductivity as low as 12-13 with a pH of 6.2, that rose to 6.4 on shaking to bring it into equilibrium with the air of the laboratory. The exceptions to the statement that in artificial waters conductivity will be due to organic solutes will be furnished by receptacles containing rain-splashed earth or air-borne dust.

Here, again, as indicated in the previous Section, there seems to be the possibility of the existence of biological races of the same species. One such observation may be here quoted. The table shows *Anopheles vagus* to have toleration limits of 100 to 600, whilst the single observation on the rather uncommon *A. jamesi* is at 344,

III.

($\times 10^6$) *Records.*

of times, the second the total larvae, found.]

[illegible]

but I have taken both species together at Trincomali, just within the mangrove zone, in water with a conductivity of 27,680, a value approximating to that of pure sea-water, although its pH was very different (6.6 corrected for salt-error) from that of the latter. This observation is the more important in that it has been suggested by Vogel that *A. vagus* breeding in saline water is a malaria-carrier, whereas when breeding in fresh water it is of little or no importance in this respect. That a large number of species normally occurring in fresh waters will breed in brackish or even pure sea water is apparent from the summary given by Balfour (1921), indicating that for such species there must be two tolerance limits, one, probably comparable with those found for most of my Ceylon species, of under 1,000, and the other, applicable to littoral conditions, of up to 37,500 or more, which is the value of pure sea-water in mid-harbour at Trincomali, taken from the surface under a blazing sun during dry weather.

V. Dissolved Oxygen Requirements.

The data obtained are recorded in Table IV in milligrammes of oxygen per litre of water. This work has been mainly carried out as part of the routine observations on certain selected bodies of water, and therefore not so many species have been

TABLE IV.

Oxygen Records (in milligrammes per litre).

[The first figure in each column is the number of times, the second the total number of larvae, found.]

Species.	0	<1	<2	<3	<4	<5	<6	<7	<8	<9	<10	<11	<12	<13	<14	<15
<i>Anopheles aithkeni</i> ...	—	—	—	—	2	2	—	—	1	3	1	1	2	—	—	—
„ <i>barbirostris</i> ...	—	—	2	2	—	—	1	12	42	3	1	—	—	—	—	—
„ <i>sinensis</i> ...	—	—	—	2	6	—	3	6	12	82	4	—	—	—	—	—
„ <i>jamesi</i> ...	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—
„ <i>hstoni</i> ...	—	1	12	76	253	43	187	139	227	533	5	1	2	1	1	2
„ <i>maculatus</i> ...	—	1	33	214	196	363	88	278	736	204	5	1	12	3	1	6
„ <i>vagus</i> ...	—	2	17	—	2	5	1	2	1	8	—	1	25	—	—	—
<i>Uranotaenia campestris</i> ...	—	2	25	2	13	3	26	2	7	1	3	3	5	1	6	1
<i>Rachionotomomyia aranoioides</i>	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Stegomyia suguens</i> ...	—	—	—	—	—	—	—	1	7	—	1	4	—	—	—	1
„ <i>albopicta</i> ...	1	12	—	—	—	—	—	1	39	—	—	—	—	—	—	—
<i>Finlaya macdougalli</i> ...	—	—	—	—	—	—	—	1	50	—	1	4	—	1	4	—
<i>Lutzia fuscana</i> ...	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Culex bitaeniorhynchus</i> ...	1	1	—	2	6	2	9	1	12	4	3	7	—	1	2	—
„ <i>whitmorei</i> ...	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—
„ <i>mimulus</i> ...	—	1	2	—	2	8	1	1	—	1	1	—	—	—	—	—
„ <i>tritaeniorhynchus</i> ...	—	2	4	—	1	2	1	—	—	—	—	—	—	—	—	—
„ <i>vishnui</i> ...	—	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—
„ <i>fatigans</i> ...	—	—	—	—	—	—	—	—	—	1	21	—	1	200	—	—
„ <i>fuscocephalus</i> ...	—	1	3	1	11	—	1	1	—	—	—	—	—	—	—	—
„ <i>castrensis</i> ...	—	—	—	1	12	22	—	—	—	—	1	12	1	1	—	—
„ <i>minutissimus</i> ...	—	1	33	27	2	23	1	11	12	33	94	102	3	—	—	—
<i>Dixa zeylanica</i> ...	—	—	—	—	1	1	1	11	35	153	63	14	1	—	—	—

encountered as in the other investigations. Also, a much greater bulk of water has to be carried about in obtaining samples for this investigation than for the two previous lines of work, rendering it less adapted than the former for field work far from the laboratory. Hence only 50 per cent. of the species on which pH data are available have yielded figures of oxygen requirements, and on only two of these, but fortunately the two common malaria-carriers of the Ceylon sub-montane zone, has any considerable number of observations been made. For these two species

the data show that there is a complete tolerance, ranging from water with only 0.40 mg. per litre in the case of *A. maculatus*, and from 0.87 mg. in the case of *A. listoni*, up to supersaturation values of 14.84 mg. and 12.32 mg. per litre respectively.

But though it is thus shown that there is a complete toleration for at least these two species, it may be well doubted if this is real and not apparent, at least on the lower side. The finding of odd larvae under exceptional circumstances does not necessarily connote that they are then in a suitable environment, or that they will be in a position to complete their development in it. Sometimes, indeed, as in the single instance where *A. maculatus* was found with only 0.40 mg. per litre the larvae were obviously diseased, and probably, if left alone, would have failed to emerge as adults; but the point is a very difficult one to check. Transfer to breeding bowls in the laboratory so alters conditions that emergence or death cannot be attributed to the originally discovered circumstances, which cannot be reproduced artificially with the resources of an ordinary laboratory. The point can only be decided by very refined experimental methods, or by the accumulation of a much longer series of figures than is offered here. All that can be said so far is that, contrary to what has been found with other aquatic animals, there seems to be no sharp limiting factor in oxygen.

It is a well-known fact that fish, for instance, are indirectly very sensitive to oxygen supersaturation, and are even liable to disease under such conditions (Moore, Prideaux & Herdman, 1915) owing to the high alkalinity; this is occasioned by photosynthesis

TABLE V.

Date.	pH	Residual pH.	Oxygen mg. / ₁₀₀	<i>F. macdougalli</i>	<i>S. sugens.</i>	<i>C. fatigans.</i>	<i>A. maculatus.</i>	Remarks.
9.xi	9.6	?	12.0	A few	—	—	—	Emergence commencing. Oil still catching adults.
15.xi	7.2	7.1?	6.4	50	7	—	7	
16.xi	8.6	7.8	10.1	4	—	Egg mass	—	<i>F. macdougalli</i> pupating.
18.xi	9.6	8.0	14.8	4	1	+++	4	All except <i>C. fatigans</i> pupating.
19.xi	8.6	7.8	8.8	2	4	+++	1	do. do.
20.xi	8.4	7.8	?	4	2	+++	—	<i>C. fatigans</i> mature and pupating Fresh brood of <i>F. macdougalli</i> and <i>S. sugens</i> starting.

which liberates oxygen. But the effect on mosquito larvae seems to be the reverse, causing them to be found in situations, and at pH values, quite outside their normal limits. In November 1924 a steel barrel, partly sunk in the ground and used as a garden water-butt, was found to contain larvae, although the surface of the water in it still showed iridescent streaks from previous oilings. The complex of species was unusual. There were the two generally associated with such a situation, *Stegomyia sugens* and *Finlaya macdougalli*; during the course of the investigations of the breeding-place *Culex fatigans* appeared, an extreme rarity in the locality in which the barrel was found (Senior-White, 1921), though the place was not an unusual one for that species, especially when it is considered that there are nearly always dead toads and snails at the bottom of such collections of water; but the surprise was the presence of a healthy family of *Anopheles maculatus*, a species that had never heretofore been found in the barrel, which, being in my own garden, was under constant observation. On this occasion frequent examinations of the place were made until the approaching maturity of an excessive number of *C. fatigans* rendered oiling again necessary.

The conductivity of the water was low, around 87, it being rain-water. The *A. maculatus* were all of one family, those found on the 15th being young, those of the

18th mature, and that of 19th was taken as a pupa. The source of the hyper-oxygenation of the water was an almost pure culture of the Volvocale *Gonium*, with which were associated a few Ciliate Protozoa and Rotifers of the genus *Philodina*. The water was green by transmitted light.

The residual pH value, in air-equilibrium, shows that these exceptionally high natural pH values are a super-addition, and that the residual values are within the normal ranges of the various species present. Several examples of high pH values in association with active photosynthesis are given by Atkins (1922) and Atkins & Harris (1924). In the case under discussion the amount of animal life was very small in comparison with the vegetable.

In regard to the artificial-water breeders, it will be seen that there are very few observations. The reason for this is that it is exceptional to find them in collections of water of sufficient size to yield the 150 cc. required for the determination of oxygen. Hence it has been impossible to investigate the point suggested to me by Dr. Ritchie, of the Royal Scottish Museum, viz., the correlation of the length of the anal papillae of the larvae of various species with the oxygen content. That these anal papillae to some extent function as gills is generally accepted (Patton & Cragg, 1913, p. 200). It is noteworthy that they are nearly always larger in bottom-feeders than in surface-feeders, the latter not experiencing the same necessity for skin-respiration as the former, as pointed out by Wesenburg-Lund (1921, p. 26), and reach their maximum development in *Armigeres obturbans*, a dweller in extremely filthy water.* On the other hand *Lutzia fuscana*, which at times preys on *obturbans* and must therefore be able to tolerate similar conditions, though quite possibly not to the same extent, has only small, rounded knob-like anal papillae. As the species is a surface-feeder, inasmuch as it usually captures its prey whilst the latter is swimming and not feeding, this is in accordance with the general proposition of Wesenburg-Lund, who, however, states elsewhere (*op. cit.*, p. 15) that the length of the papillae may vary within the species, and that these organs are most strongly developed in dark, peaty water. It is noteworthy that the only measurements of the oxygen-requirements of *L. fuscana* that have so far been made both showed a content of less than 1 mg. per litre.

VI. Saline Ammonia Toleration Limits.

The results of this work have been most disappointing. The limits of accuracy of the method used are low, for owing to the necessity in nearly all cases of precipitating magnesium and calcium salts with CuSO_4 and NaOH before Nesslerisation, a slight opacity in the water, obscuring comparison with the fainter Nessler tints, has resulted. When ammonia has been present in sufficient quantity to be measurable by the method used, it has usually been correlated with mosquito-sterility, but the limit of delicacy is far above the quantities found in the analyses published by Lamborn (1922, Tables IV and VI), carried out by more refined methods in a properly equipped laboratory, hence nothing can be stated with certainty concerning the ammonia factor until methods of similar delicacy can be adopted here. In any case a study of Lamborn's tables would indicate that it is not the saline but the albuminoid ammonia that is the biologically important factor. After several months' trial of the direct Nesslerisation method the investigation of this point was suspended, for it had yielded very few results at all.

In so far as they indicate anything, these tend to show that amounts of even less than one part per million of saline ammonia are inhibitory to natural-water breeders. The same difficulty as in the case of oxygen has been experienced in the

* Though, as pointed out by Wesenburg-Lund (*op. cit.*, p. 101), it is very hard to understand how cutaneous or anal-papillar respiration can be of much use to a larva under poor oxygen conditions. Referring to very foul, faecal-contaminated water he states (p. 129) that under such conditions atmospheric respiration is a *sine qua non*.

case of artificial-water breeders, namely, insufficient water for the test. In one instance a puddle in a swamp, which contained dead snails, and the water of which stank, gave a deep orange colour with Nessler that, had sufficient been available for measurement, must have far exceeded the quantities obtained elsewhere. The species found (in fair numbers) and which successfully emerged were *Culicomyia pallidothorax*, *C. fragilis* and *L. fuscana*. These three species at least must be able to tolerate a high concentration of saline ammonia and, from the circumstances, probably of albuminoid ammonia also.

VII. The Toleration-Limits of the Various Species.

In Tables I to IV, in which the data of the various factors are summarised individually, the species are arranged in systematic order. Owing to their very diverse habitats within the genus this is not the best way of bringing out their relationships to one another ecologically, though more useful for reference purposes, and in figure 1, in which the limits, as yet known, of each species (with, when possible, an indication of the optima) in respect of their pH, conductivity and oxygen requirements, are shown diagrammatically, the species are grouped in accordance with their faunal associations.

In spite of the exceptions that not uncommonly occur, such associations are a very real thing, and, if his own results be analysed, the criticisms of Lamborn (1922) hardly seem justified; for most of his own data only add confirmation to Hacker's hypothesis. These may be referred to here.

Page 3.—What is an "old boat" but a "small, open pool", when filled by rain? In the case referred to it contained *A. vagus* 100 per cent., thus agreeing with the hypothesis. The fish-pond in which the boat floated, being large enough to require such a means of working it, must surely come within the definition of a "large, swampy pool". It contained 83 per cent. of species belonging to Group II, associated with this form of water, and thus again supports the preference. The "small, muddy pools" examined on 1.xii.1920 contained 80 per cent. of Group I species; again confirmatory. The second group of small pools, examined on 15.iv.1920, which showed only 8 per cent. of Group I species, certainly tell against the hypothesis. The fish-pond, in examinations up to 22.iii.1920, confirms the hypothesis by yielding 96 per cent. of Group II species, but the examination of 29.iii.1920, revealing only 19 per cent. of species of this Group, would indicate that during the intervening week a great change had occurred in some factor, causing Group I conditions, which evidently persisted on 26.viii.1920, when there was still 83 per cent. of Group I species and only 17 per cent. of species properly associated with the situation; but when further examinations of this (or another) fish-pond were commenced on 29.x.1920 (Table II, p. 5), 90 per cent. of Group II species were found over the ensuing six months. The almost complete absence of *A. aconitus* does not in any way invalidate the general hypothesis, for Hacker hardly attempted to sub-divide his Groups.

Page 7.—Swamp L, and ponds K, N, O and P all contained 100 per cent. of Group II species.

Page 9.—The pond referred to in paragraph 2, again, shows 100 per cent. of Group II species in a Group II breeding-place.

Thus, with two exceptions, all Lamborn's results only serve to confirm the general truth of the hypothesis enunciated by Hacker.

In my opinion, these associations are fundamental. In the reasons which underlie them are hidden everything that has any bearing on the bionomics of each species; in other words, they represent the product of the interaction of all the physical and chemical factors which it is the object of the present research to elucidate in measurable terms. The action of the product is, I agree with Lamborn, an "urge"

to oviposition and not an elimination of wrongly placed ova. As he states (*op. cit.*, p. 10), "... the female mosquito, like other insects, is probably influenced in her choice [of breeding-places] primarily by the odours characteristic of particular spots, which connote the *general suitability of the situation as to temperature, composition of water, presence of particular foods*" (the italics are my own). As I hope to show subsequently, the third requirement is bound up in the second. Whatever may be its effect beyond the Tropics, within them the temperature factor probably has very little action, save perhaps in controlling the vertical distribution of the mosquitos. Again, Wesenburg-Lund (1921, pp. 137-138) shows that ovipositing females can select the sites of future ponds six months ahead of the time when snow-fall will start to create them, picking out such situations when there is no obvious depression in the terrain to indicate the sites to the human eye. Such a discrimination can only reside in the most delicate perception of humidity which, even in dry weather, is probably greater over an old pond-site than elsewhere in the neighbourhood.

Now unfortunately it is not possible to collate the situations which have mainly been under examination during the course of my work with those on which Hacker based his Group-classification, for in all the Malayan work there is little mention of rice-fields, which, judging from Hacker's placing of the Anophelines found in them that are common to both countries, represent a situation intermediate between the "small open" and "large, swampy pools" of the Malayan writer's Groups I and II. All that I can at present do here is to divide the natural-water breeders into two groups, depending on their association with moving or with more or less standing water.

In respect of the artificial-water breeders, we reach untouched ground. The following diagram shows how artificial collections of water may be divided, with the complex of species common to each division.

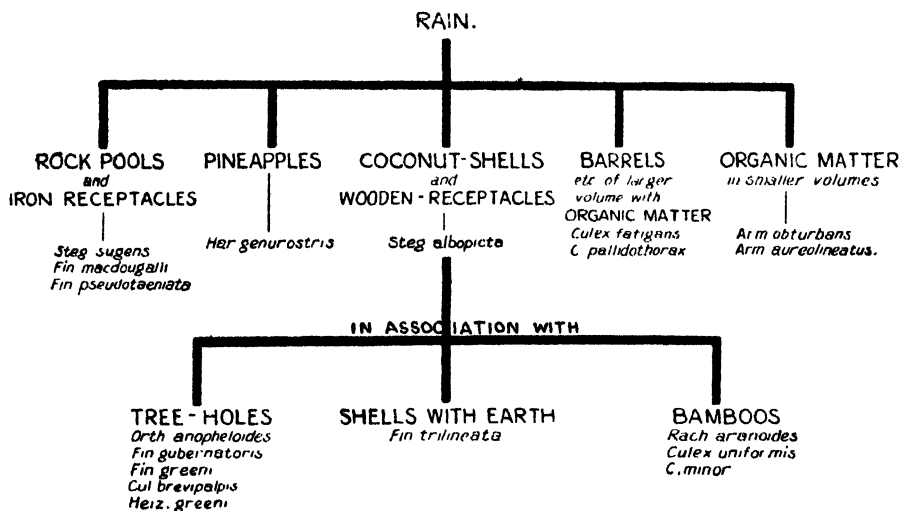


FIG. 2. The water relationships of the artificial-water breeders.

It is not suggested that these divisions are absolutely definite, but the diagram serves to bring out the principal divisions of artificial water, and the sources of the various quite unknown organic admixtures which must be added to rain-water before *Stegomyia albopicta* is joined by the specialised species of tree-holes and bamboos.

We can now comment on the various members of each association separately. When a species has been found on each side of a certain value for any factor, but not at that particular value, it has been assumed, as has been done by Atkins & Lebour

(1923) in dealing with snails, that it will also tolerate the intermediate value. None the less, where gaps, especially around neutrality in pH, are seen in Table I, it should be remembered that certain animals, such as fishes, really do avoid neutrality, as pointed out by Shelford (1918), and that therefore it is possible that the occurrence of such gaps in the toleration range is a real phenomenon.

A. MOVING-WATER GROUP.

Anopheles leucosphyrus, Dön. A forest-breeding mosquito belonging to Hacker's Group II. It has not been found sufficiently often for anything definite to be said concerning it. Not only is it an extreme rarity in Ceylon, but I think the situations where I have found it do not represent its true habitat, but that such have been no more than the results of washing down by floods from forest above.* In practically every case that has come under my notice it has been associated with *A. maculatus*, whereas Hacker (1920) only gives a 2 per cent. association with that species. Its occurrence in very acid water of high purity is, however, what one would expect for a mosquito of hill-forest stream habitat.

Anopheles ailkeni, James. I cannot agree with Watson's (1921, p. 288) dictum that the shade of rubber (*Hevea brasiliensis*, Muell. Arg.) is insufficient for this species. On every occasion when I have taken it, it has been among rubber, and on practically every occasion it has been in association with *A. maculatus*, sometimes with *A. listoni* also, and once with the latter species alone. Hacker gives for it only a 5 per cent. association value with *maculatus* and has not apparently found it with *aconitus*, which represents *listoni* in Malaya. I have found *ailkeni* more than once under a blazing sun among leafless "wintering" rubber, beneath the fallen leaves which at that time of year thickly carpet the slowly moving ravine-streams of an estate. The data available on it are not numerous, but it is seen to tolerate acidity up to the natural limit at 5.8, with a lesser extent on the alkaline side, and to require water of considerable purity, as revealed both by low conductivity and high oxygen content.

Anopheles karwari, James. An uncommon species in Ceylon, and invariably in my experience with *A. maculatus*. My very insufficient data show high acidity and very low conductivity values for it. It is probably much more specialised in its requirements than *maculatus*, which would account for both Hacker (1920) and myself (Senior-White, 1921) finding much lower values for its association with *maculatus* than for the latter species in association with it, 5.9 per cent. and 1.5 per cent. respectively, as against 17.2 per cent. and 100 per cent. in the reverse relationship. *A. karwari* is usually found, in Ceylon, in situations where the water is flowing over rock rather than earth, and usually is arising from a deep-level spring in rock not far off.

Anopheles maculatus, Theo. This species, which is the chief malaria-carrier throughout the lower hills of the Eastern Tropics, has, unfortunately, extremely wide tolerance-limits, the tables showing it to extend throughout the natural range of both pH and conductivity, and through all oxygen contents from less than 1 mg. per litre up to nearly 90 per cent. supersaturation. None the less, in reality these limits are probably not so wide as they appear. Reference to Table I shows that, in pH, the record is not continuous for values beyond 8.0, that there is a gap up to 8.6, and a further big jump to the limit at 9.6. As a matter of fact, these observations at exceptional values are the result of artificial conditions, and it is necessary to deal with them in some detail.

The more "natural" of the two observations at 8.6 was made in a stream that in its course traversed a quarry in the magnesium-limestone of the Ceylon foot-hills, trickling down the face of the exposed rock. During this process it is able, by virtue

* Whilst this paper was in course of preparation, *A. leucosphyrus* has been found in springs at the head of a ravine with only very light shade, in company with *A. maculatus*. There was no forest of any kind within some miles.

of the CO_2 originally contained in it (the pH above the quarry being 6.4), to dissolve out an appreciable quantity of the carbonates of magnesium and calcium. In trickling down the face of the rock the water would be brought into equilibrium with the air, and thus rendered more alkaline, as is shown by the rise in value at the foot of the quarry to a normal of 7.8, where occurred pools in which the larvae were found. During July blasting operations, which had been in abeyance for some months, were resumed, exposing fresh surfaces of rock to leaching, and the pH value rose to 9.2, at which no larvae were found. As shown by Atkins (1922, p. 732-3), though the hydroxyl-ion concentration producible by calcium hydroxide is greater than that arising from magnesium hydroxide, yet owing to the lower solubility of calcium carbonate and its greater resistance to hydrolysis, the limiting pH value for the calcium salt is below that for the magnesium salt, and cannot exceed pH 9.01. Thus in the case under discussion it is probable that before fresh surfaces were exposed by blasting all the magnesium content of the rock available to the water had been leached away, and the pH value was a calcium effect only, whilst after blasting, the high value reached was due to the fresh surfaces containing magnesium salts exposed. These, however, must have been very rapidly dissolved, for less than three weeks after the cessation of blasting the value had come down to within the calcium limit, and larvae were more numerous than ever before.

TABLE VI.

	May.	June.	July.	August.	September.	October.
pH above Quarry ...	—	—	—	—	Flushed	6.4
pH at foot of Quarry ...	7.8	7.8	9.2	8.7	out by	8.9
$\text{C} \times 10^6$...	—	—	—	100	very	—
<i>A. maculatus</i> ...	5	3	0	27	heavy	Again
<i>U. campestris</i> ...	0	0	0	1	rains.	flushed out by heavy rains.

The second observation at this value, and the single one at pH 9.6, relate to an exceptional locality and set of conditions which have already been described in Section V. As there shown, if the oxygen supersaturation be removed, the pH of the water on these two occasions was 7.8 and 8.0 respectively, or within the usual limits of the species, which, I think, can therefore be placed on the alkaline side at 8.0, and this brings it into line with the remainder of the moving-water group.

These observations show the immense biological difference between a pH due to hyperoxygenation and one due to true alkali, though both be of the same value. In the first case we have larvae flourishing at 9.6, in the second we see a value of 9.2 inhibitory to their presence, and until values due to various sets of circumstances are distinguished, as commenced in this paper by evaluating the "residual" pH, so long will pH work continue to afford instances of apparently contradictory observations. The need for distinguishing pH-causes does not seem to have been hitherto appreciated, the only reference to anything of this nature being the remarks of Atkins & Lebour (1924) in connection with CO_2 -caused values.

The occurrence of *A. maculatus* in artificial breeding-places, such as that instanced in Section V, has been referred to by Hacker (1918, 1919), and it would be interesting to learn if future findings of the species in such situations are always associated with the presence of green algae, as was obviously the case in my finding, and has been suggested by Lamborn.

In respect of solute-tolerance, *A. maculatus* again has the widest range possible to natural-water breeders, a range which is only shared by the *Uranotaenia* closely associated with it, and by *A. listoni*. In respect of oxygen requirements, though it has been found at the lowest amount which has yielded me "natural-water" larvae,

viz., 0.40 mg. per litre, it is doubtful if it will really tolerate such low values, as referred to on page 197. That very high hyperoxygenation has none but a beneficial effect on development the results on page 197 clearly show. In this case the larvae developed swiftly and normally, without a single casualty, yielding large-sized adults, which is the very opposite to the case with larvae originally found under low oxygen conditions that probably become worse in breeding bowls in the laboratory.

Wide as the toleration-ranges are, it will be seen that they have values at which the number of times the species has been found greatly exceed the numbers at other values, and it must be supposed that these represent the optima for the species, departures from which imply a decrease in metabolic activity and consequently in vitality. These limits can be placed at pH 6.8-7.0: $C \times 10^6$, 200-300: O_2 , 5-7 mg. per litre. Once these optima for all factors have been definitely determined for a species, it should be possible to calculate the percentage chances of its existence or survival for all permutations of the value of each factor within the tolerance range, thus explaining the still incomprehensible cases where water with all known factors within its tolerance-range still does not show the presence of a particular species.

It will be seen that the tolerances of *A. maculatus* more than cover the ranges recorded for *A. aikeni*, *A. leucosphyrus* and *A. karwari*, shown previously to be closely associated with it, whilst the much more restricted ranges of these species explain why their individual association values for *A. maculatus* are so much lower than the reverse relationships.

Anopheles listoni, List., is the only other malaria-carrier of any importance on which results have so far been obtained, and the species concerning which there are the most data available. It will obviously not tolerate so high an amount of acidity as the preceding species, and the manner in which a greater number of observations than unity at pH 6.2 are followed by complete absence of the species from the next and all subsequent values strongly suggests that 6.2 marks its absolute tolerance limit on the acid side. On the alkaline, though the range extends, with a gap, to the common natural-water limit at 8.6, there is such a sharp fall-off in the number of observations at the highest values that the usual limit for the species may be put at 8.0, extensions beyond this point being due to exceptional circumstances. Thus, the single observation at 8.6 refers to the finding of larvae among a clump of *Limnophila* in an irrigation tank, where photosynthesis was proceeding strongly. Two feet outside the clump the water stood at 8.2, and it is therefore clear that the additional hydroxyl-ions were the result of active photosynthesis only. The case is therefore parallel to that quoted in Section V. The equilibrium with air pH of the water among the *Limnophila* must have been less than 8.2.*

The observation at 8.2 was made at the same time as the preceding, and a few yards away, again among *Limnophila*, but in this case where it was overhung by *Panicum crus-galli*, which shaded the water-plant from extremely active photosynthesis. At this spot, also, there was more current, the point being the commencement of the outlet channel from the tank, so excess of oxygen would probably not occur to the same extent. Here the pH away from the *Limnophila* was only 8.0, indicating that the microflora of the nearly stagnant tank-water at the first site was producing a rise in pH of itself, affecting the last figure in the previous paragraph.

In regard to the single observation at 8.0, this, being associated with an oxygen content of 6.60 mg. per litre only, is not a hyperoxygenation effect, and thus represents the highest concentration of air-equilibrium alkalinity at which the species has yet been found, and its limiting value for this factor.

* It has been pointed out by Atkins & Harris (1924) that in the case of a hard water a pH of over 8.1 denotes approximate oxygen saturation.

Turning to solute-tolerance, it will be observed that though the species has been found up to the natural limit of $C \times 10^6 = <1,000$, it is very rare in extremely pure waters of <100 , and there is a sharp rise in the number of observations at the next value above, indicating that the species is not usually found in such very pure waters, which are mainly those of springs, a situation not favoured by *A. listoni*.

In respect of oxygen requirements, it has been found at concentrations of from less than 1 mg. per litre, right up to considerable hyperoxygenation values. At the lowest concentration, 0.87 mg. per litre (which is however more than twice the lowest recorded for *A. maculatus*), a single pupa only was obtained, whereas in the same spot during the previous two weeks, when the water held 2.13 mg. and 1.07 mg. per litre respectively, larvae had been quite numerous; and it is probable that, as pH remained over this period fairly constant, the controlling factor here was oxygen, and that in the last week, when the single pupa was found, the species had ceased to use the spot as a breeding-place.

Considering these results together, the optima for *A. listoni* become fairly certain. They are: a pH of 6.8–7.0; a conductivity of 300–700; and an oxygen-content of 5–7 mg. per litre. The much shorter pH tolerance-range, and the inability to tolerate very pure water or a very low oxygen content, explains the exposition of Lamborn (1922, p. 12–13) that the very closely related *A. aconitus* is a most delicate species to rear, which is also my experience with *A. listoni*.

The foregoing results, expressed as percentages of times captured in respect of each value of each factor, are shown graphically in figure 3. The optimum values are thus well brought out, in spite of irregularities in the curves, which are obviously due to still insufficient observations.

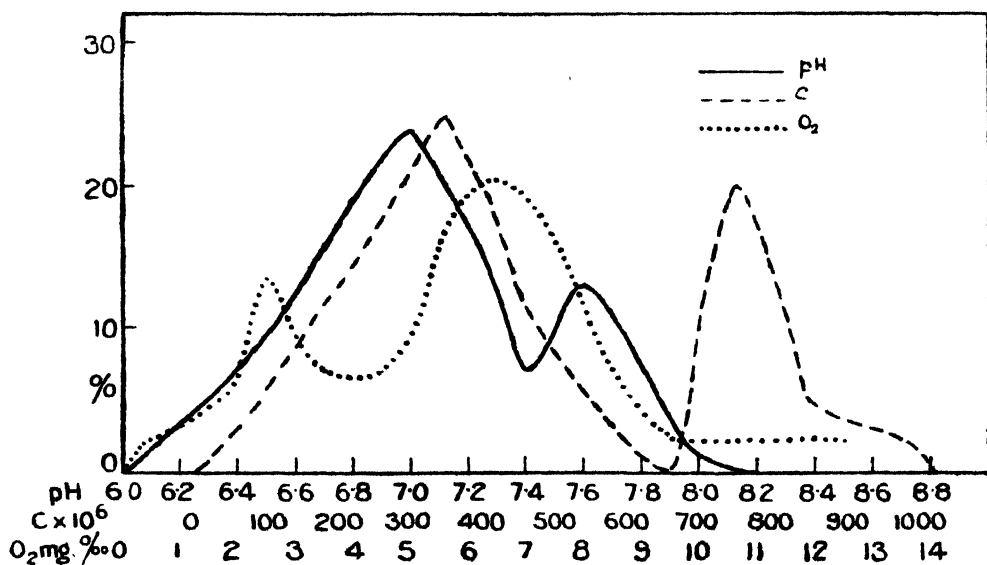


FIG. 3. *Anopheles listoni*, percentage of observations for each factor within the tolerance ranges.

Dixa zeylanica, S.-W. It is not proposed to enter here into a discussion whether or not this genus belongs to the CULICIDAE. For biological purposes it is recorded here as an "indicator species" (*vide infra*) of some value. The data on it are few, but it will be seen that it tolerates neither extreme of the natural pH range, and that, though single findings show it to have fairly wide tolerances in respect of conductivity

and oxygen, yet the majority of observations indicate that it has a preference for hard waters of about 300 conductivity, and of high oxygen content. The species is only common between January and March.

Uranotaenia campestris, Leic. Another "indicator species" for *Anopheles maculatus*, and possessing an almost identical range. The solitary record at pH 8.6 occurred in company therewith and is referred to in Table VI. The only discrepancy in the identity of toleration ranges between the two species lies in the fact that the one now under discussion is apparently not found in hyperoxygenated water, but as the 8.6 record probably occurred in such water (*vide* footnote on page 203), this difference is probably not a real one. As regards optima, that for pH is obviously 7.0 and conductivity 300-400, but for the oxygen factor the data are so evenly distributed that until further records have been accumulated it is impossible to state anything.

I have referred to the two foregoing species as "indicator species," meaning that their presence is indicative of the suitability of the water containing them for some more important species, in this case *A. maculatus*. Now the larval *Dixa zeylanica* is a very distinctive organism, and very easy to capture, for if scooped up in the usual long-handled ladle it almost invariably at once adheres, bent V-shape, to the side, and is impossible to overlook. In regard to *U. campestris*, the larva is less active and less definitely attached to the margins of water than is the Anopheline, and so rather more certain of capture, whilst the bright yellow body and black head make it very distinct even to the naked eye. The presence of either species should stimulate a further search for *A. maculatus*, if it has not already been taken, and also serves as a warning that the water under examination is at any rate quite suitable for the latter, even if prolonged search indicates that it has not yet invaded it.

Culex castrensis, Fdw. A rare species, apparently of restricted range, associated with water of low conductivity. It has a high association value with *A. aitkeni*, and consequently, under Ceylon conditions, with *A. maculatus*, but the larva is in naked-eye appearance too like the next species to render it of use as an "indicator."

Culex minutissimus, Theo. A common species, but apparently of as equally restricted range as the preceding one, especially as regards pH. The high number of takings at pH 6.4, followed by absence, would almost conclusively indicate that this value is its toleration limit on the acid side, whilst on the alkaline, it would seem probable that 7.8 will be found to be its limit. It seems almost similarly restricted in regard to conductivity-toleration, avoiding equally natural waters of very low or rather high conductivity, but its oxygen requirements seem more catholic. It is only possible to indicate the pH optimum, which is at 6.8-7.0.

Culex bitaeniorhynchus, Giles. This is the only mosquito concerning which it is possible to dogmatise definitely in respect of habitat, for without a doubt it is completely attached to the genus *Spirogyra*, and cannot live apart from it. Among the algal filaments the bright green larvae are extremely well protected, for I have at times scooped up small fish along with the algal masses and found the latter thick with larvae, which would not have been the case if the fish could have got at them. None the less the toleration-range of the species in respect of pH is less even than that of individual species of *Spirogyra*, as the following observations show. On one occasion I found an irrigation channel, at pH 7.0, full of the alga, with numerous larvae attached to it. The water was passing from the channel into the rice field it served through the usual bamboo pipe used in Ceylon, and had carried with it long strips of the alga into the rice-field water at pH 8.0, as measured among the alga in the rice-field, the value having been the same at that spot the week previous, when the alga had not been carried through the pipe. By careful traction I ascertained that the algal mass was continuous from the channel to the field, but the mosquito had not entered the latter with its host-plant. Subsequently, on one

occasion, *C. bitaeniorhynchus* was found at pH 8.0, but the observation stands unique, and this value is beyond the normal range.

That this species cannot live apart from the alga is easily seen in the laboratory. Here the alga usually dies within forty-eight hours, and when this occurs the larva loses its green colour, turns to the usual dirty brown of a *Culex* larva and dies, even though it be well on towards maturity.

Dissection shows that the food of the larva is *Spirogyra*, the chromatophores of the alga being found in a compact mass in the intestine, though the degree of comminution of the sheath varies. In the gut of the newly-emerged adult mosquito is found a mass of green material, which must have a larval origin, the nature of which, though obscure, shows how closely the green colouration (? chlorophyll) is bound up with the bionomics of the species. Structurally, too, the larva is somewhat modified from the general *Culex* type; the antennal fan is small and the individual hairs composing it are simple, not plumose, which would tend to show of itself that the larvae are not plankton-feeders, for the great developments of these fans in plankton-feeders, as shown by Wesenburg-Lund (1921), is connected with their use as a strainer to hold back too large particles, and to form a closed space in which the flabella can create a vortex. Further the mentum of *bitaeniorhynchus*, which is figured by Barraud (1923), is not armed with the large teeth of most of its congeners, but is extremely finely serrate and more elongate, indicating a different type of food requiring more minute trituration. This would apply to the extraction of the contents from algal filaments. The greater security in which the larvae live is indicated by the absence of plumosity from the three pairs of post-antennal hairs, which is quite exceptional in the genus. Plumosity in Arthropod hairs is stated to have an auditory function (Calman 1909, quoted by Flatterly & Walton, 1922, p. 226).

That not every species of *Spirogyra* will serve as a host to *C. bitaeniorhynchus* is very probable. A species epiphytic on *Chara zeylanica* is not so used. The toleration-limits of *bitaeniorhynchus* are narrow. It is only exceptionally found, in regard to pH, outside the range 6.6-7.2. In regard to conductivity, 200-500 seems to be all its range, and in regard to oxygen it is not generally found in water of either a very low or very high content. The single instance recorded in Table IV where the larva was found in water absolutely without any oxygen is described in Section X, but here the single larva had deserted the dying mass of *Spirogyra* and had lost its green colour. The avoidance by this mosquito of highly oxygenised water is not easily understandable. Foul water with low oxygen content would be fatal to the *Spirogyra*, but why the metabolism of the latter does not result in higher oxygen values than those recorded is a botanical problem that I will not attempt to discuss. Possibly it is connected with the fact that most of the species with which *bitaeniorhynchus* is associated are dwellers in running water, though it is not unknown from among still-water species, for which reason it is discussed last of the running-water group of mosquitos.

B. STANDING-WATER GROUP.

Anopheles fuliginosus, Giles, is a species of the low-country, seldom crossing the 1,000-foot contour. I have too slight an acquaintance with it to write with any certainty, and, in any case, most of my data being from near the upper limits of its geographical range, they are possibly not typical for the species. The gaps between the individual records are very great. The only highly alkaline record, at pH 8.6, was obtained in company with *A. listoni*, and has been described under that species, it being shown that this value was a supersaturation effect, with a true value of probably 8.0 only. I have only one conductivity and no oxygen records for the species.

A. fuliginosus is very common during the autumn in the neighbourhood of the Agricultural Research Institute at Pusa, in North Bihar, breeding along the edges

of the River Gandak, which Atkins (1923) has shown to be at pH 8.5 or thereabouts. It has been shown by Ross (1910) to be a doubtful carrier, though Carter (1921) records it as both naturally and experimentally infected, but as Fry (*q.v.*) attributed very little importance to it in respect of malaria causation in Bengal (a province which formerly included the Pusa district), it is probable that the rarity of malaria at Pusa referred to by Atkins was due to the fact that at the time that author made his observations at Pusa it was the only Anopheline about. Had Atkins remained at Pusa until the rains of the following year, he would hardly have thought that throughout the year "the necessary Anopheline carrier is rare or absent." On the other hand, it is highly likely that he is correct in supposing that the carrier (in this case *A. culicifacies*) requires, if not an acid, at least a less alkaline medium, for this species breeds in rain pools, which are probably much less alkaline than the river on the intensely alkaline soils of Bihar.

Anopheles jamesi, Theo. A not very common species, which also has not been taken by me sufficiently often for useful discussion. The pH 8.6 record again refers to the case discussed under *A. listoni* and applicable also to the previous species, but from pH 6.4 to 7.8 the records are continuous, for of the two 7.8 records, one is at 7.7, and so might with almost equal propriety be tabulated at the next lowest value, thus providing a series of single observations at every value between the above two extremes, preventing any speculation as to the optimum. The single conductivity record is typical for the average value in the rice fields, where the species is commonly found, but the corresponding oxygen value is high. The species, however, is one of those probably having a biological race suited to brackish water, for I have taken it in such, with a conductivity of 27,680, in the mangrove zone at Trincomali, though the pH, 6.8 (7.1 residual), was very different from that of the sea itself.

Anopheles barbirostris, Wulp. Here once again, of the pH 8.6 records one relates to the same spot as has been referred to previously under *A. listoni*, the other to a pond in full sunlight with *Spirogyra* and *Closterium* in such active photosynthesis that the surface was all bubbles entangled in the algal filaments. The species has a pH toleration of from the natural-water limit of acidity upwards, but there are not very many records until 6.4 is reached, whilst on the alkaline side the drop in the number of observations after 7.8 is still sharper. The optimum is distinctly 6.8-7.0. The conductivity toleration is ± 400 from the mean, whilst all oxygen contents, except those of less than 1 mg. per litre, up to supersaturation are tolerated.

Anopheles sinensis, Wied. Of even more restricted range than the previous species, inasmuch as it seems to possess very little acidity toleration indeed, whilst on the alkaline side all observations beyond 7.4 are the result of supersaturation. Of the two at pH 8.6, one is identical with the oft-quoted one described under *A. listoni* (it is thus seen that this particular spot served the requirements of no less than five Anophelines), the other was in a pool in forest, covered with *Notosacra brachiata*, Wgt., and which, in spite of there not being a full incidence of sunlight, was thick with a large species of *Volvox* that must have strongly hyperoxygenated the water. The feeding of this species on *Volvox* has been previously noted by Lamborn (1921). The single observation at pH 8.2 is identical with that described under this value for *A. listoni*, and as below this there is a gap, it would appear that *A. sinensis*, common as it is in many places, has a very restricted pH tolerance. In regard to solutes, it would appear to require rather purer water than *barbirostris*, but to have the unusual feature of the optimum coincident with the maximum, whilst its high lower limit for oxygen-content also indicates that organic pollution is not tolerated.

Anopheles vagus, Dön. As I have shown elsewhere (Senior-White, 1921), this species is not nearly so common in my experience as it seems to be in that of workers in other areas of the Region. Probably the reason for this is that, as the data which will now be discussed show, its tolerances are very restricted, and possibly other localities within its geographical range contain more habitats suited to it than do the

Ceylon foot-hills, where most of my observations have been made. My data reveal a very high degree of intolerance to acidity, there being only a single record below pH 6.8, at which value there are several, and an equally sharp drop beyond 7.4; for while the recorded toleration extends to 7.8, at which value I have twice found the species, once in large numbers, on both occasions the larvae were badly attacked by ectoparasitic Protozoa, as was also the case with the single record at 7.6. The pH optimum is probably around 7.2, or distinctly more alkaline than that of any species so far discussed. The solute-tolerance is narrow, and like that of *A. sinensis*, seems to have its optimum coincident with its maximum, though the species, being recorded from brackish water, probably has a second biological race, in this case of extreme importance, if it is really a fact that females so bred are malaria-carriers. I have so taken it along with *A. jamesi* in circumstances recorded under the latter species.

Now *A. fuliginosus*, *jamesi*, *barbirostris* and *sinensis*, belong to Hacker's Group II, *A. vagus* to his Group I. Bearing the results above recorded in mind we can revert to the observation of Lamborn (1922, p. 3), referred to at the commencement of this section, and consider why the fish-pond in which, up to 22.iii.1920, he obtained 96 per cent. of the properly associated species, a week later had apparently become a Group I breeding place. The species that Lamborn encountered were *A. barbirostris*, *A. sinensis* and *A. vagus*,* and of these the last, which became dominant, has a smaller pH range than either of the others. In respect of solute-tolerance, *vagus* is intermediate in its requirements between *sinensis* and *barbirostris*, and the optimum for all three species being the same, <500, this factor also could not have decided the point. In respect of oxygen, however, we see *A. vagus* with a toleration of a less quantity than the others, and this was probably at least one of the factors which decided its dominance. Very low oxygen-content usually denotes organic pollution and so does ammonia, and I have found *A. vagus* with a higher tolerance for this than either of the other two species. Thus the apparently contradictory result recorded by Lamborn possibly means that pools of Hacker's Groups I and II should be re-defined in terms of amount of oxygen, either dissolved or absorbed.

Culex mimulus, Edw. The pH limits of this species are apparently similar to those of *A. vagus*, the single 8.6 record being a supersaturation effect on a true value of 7.7; but in reality the tolerance is wider, as the greater number of records at the acid-limiting value show. Solute-tolerance is not very wide, but the larvae are always found in water of low oxygen-content. The association-value between the two species is, however, low, and *C. mimulus* is much more often associated with the Anophelines of Group II.

Culex tritaeniorhynchus, Giles. The single pH record at 8.6 is the same as that discussed under *A. sinensis*, a pool thick with *Volvox* and strongly hyperoxygenated. The true value was probably much below that figure, at least 8.0. Even so adjusted, this leaves a gap between the general series of records and this one, hence it would appear as if the general tolerance is a very narrow one. This is actually so in respect of solutes, on which all the observations are at one value, though further work will almost certainly somewhat extend the range. Like the foregoing species, it is usually found in water of low oxygen-content.

Culex whitmori, Giles. The observations are too few for discussion.

Culex sitiens, Wied. Numerous larvae of this species were obtained on one occasion behind the mangrove zone at Trincomali, curiously enough in company with *C. vishnui*. The pH (8.0) and conductivity (11,190) are probably typical of the requirements of this halophilous species, and may indicate the existence of a brackish-water race of *vishnui*.

* It is not clear from his wording whether *A. fuliginosus* was not also present. If it was, it does not alter the argument.

Culex vishnui, Theo. Both the pH 8.6 records are in hyperoxygenated water full of *Volvox*, and so can be reduced to at least 8.0, eliminating this cause. There are indications that the species has an optimum in acidity at 6.8. For the other factors observations are as yet too few for discussion.

Culex barraudi, Edw. Larvae apparently of this species have been found once only, pH 6.8, conductivity 729, in swampy ground below the bund of an irrigation tank. They were associated with two moving-water species, *A. listoni* and *U. campestris*, and two standing-water species, *A. barbirostris* and *C. mimulus*. As these larvae died without pupating the identification could not be checked by examination of male genitalia.

Culex fuscocephalus, Theo., is apparently a species of very restricted pH range. The single and isolated record at 7.8 refers to the finding of a single pupa, showing that the species had ceased to use the breeding-place, which had risen from 7.4 to 7.8 during a period of nine days, in which the larval stage had been passed. Conductivity requirements are in agreement with those of *A. vagus*, which is closely associated with it, and it has the usual low oxygen requirements of its group.

Culicomyia bahri, Edw., and *Culicomyia fragilis*, Ludl. The data on these two closely allied species are so few as to preclude any remarks.

Aedes pseudomediofasciatus, Theo. Though included here, this species has nothing in common with the rest of the group. It is a breeder in rain-filled pools in depressions and drains, and is quite often associated with species allocated to the moving-water group, though I do not think it can with any more propriety be placed with them. Being, in my experience, too uncommon for even group-allocation, it is obviously impossible to state its tolerances, the few observations on it, as regards pH, being close to neutrality and therefore probably in the middle of its range.

Aedes longirostris, Leic. I have not included this species in figure 1, as I have only once met with it and it has not hitherto been recorded from Ceylon. I took it just within the mangrove zone at Trincomali, in water of pH 6.8, and conductivity 27,680, in association with *A. jamesi* and *A. vagus*.

Ficalbia luzonensis, Ludl. I have not included this species either in fig. 1, as I am not aware of its bionomics, and have only a single observation on it, as in Table I. On this occasion it was found in a rice-field, along with two moving-water species, *A. maculatus* and *U. campestris*, and two standing-water species, *A. sinensis* and *C. vishnui*. The peculiar structure of the pupa (Senior-White, 1925) shows that it is modified for a special existence. Possibly it is attached to *Pistia stratiotes*. It is not a true rice-field species, and had certainly come into the field along with the two moving-water species found in company with it.

Having thus discussed in as much detail as possible the individual species of the two natural-water groups, we may now try to contrast these as a whole.

It is at once obvious that the moving-water group has wider tolerances than the standing-water group. Excluding from the latter the last three species placed therein, on which there are quite insufficient data, it is seen that in regard to pH the first group has 50 per cent. of its species tolerating a higher acidity than 6.4, as against only 13 per cent. of the second group; the former, however, tolerates alkalinity in excess of 7.8 much less than the latter. In both groups alkalinity in excess of 8.0 is only tolerated in the presence of oxygen supersaturation, but twice as many of the latter group as of the former have been found in the high pH thus caused.

In respect of solute-tolerance, the moving-water group has a lower optimum than the standing-water, <300 in one case, and <500 in the other; but the most noticeable point is, again, the very much wider tolerance of the former, extending from <100 to <1,000, whereas the latter only exceptionally enter pure water and hardly ever pass 800.

In respect of oxygen requirements, as the observations, when sufficiently numerous, are confined to a few species in each group, it is unsafe to generalise, but the moving-water group would seem to require high oxygen-content, which is only in accordance with what would be expected.

One fact, however, clearly emerges from the foregoing, and that is the much wider tolerances of the genus *Anopheles*, as represented in both groups, compared with the various species of *Culex*. This was referred to at the commencement of Section III, but it will be noticed here that of seven species which pass 6.2, no less than five are Anophelines, whilst of the ten which pass 8.0, six belong to the same genus. The standing-water species of *Culex* (most of them of the banded-proboscis-group of the genus), in particular, form a very solid phalanx of species with similar tolerations, such differences as appear between them being mainly, I think, due to lack of sufficient observations.

C. ARTIFICIAL-WATER GROUPS.

The differences in required chemical constitution of water between the various sub-groups of this section are probably far more fundamental than between the two sub-groups of natural-water species. Though in artificial waters rain is the immediate source of all the water, which is thus more uniform in original composition than the deep and shallow spring and surface drainage waters which mingle to form natural waters, yet, unless there arises contamination from mining or chemical influences, which is not the case with any of the waters discussed in this paper, the leachings from the surface of a country of a single geological formation like Ceylon are far more uniform in quality than the results from the addition of the varying organic extracts which distinguish the "artificial" sub-groups.

Rock-pool Group.—The waters inhabited by mosquitos of this group are distinguished by a generally more or less neutral to weakly alkaline reaction and a low conductivity. Water accumulated in iron receptacles largely falls into the same category. When the situation permits of active algal growth with photosynthesis to correspond, as in the water of this nature referred to in Section V, there may be very alkaline reactions, but this is an effect superimposed on an otherwise nearly neutral one, as Table V shows, on the occasion of 15th November, when oxygen was not present in excess of the saturation point owing to photosynthesis having decreased. On the three species shown in this sub-group in figures 1 and 2, I do not think it wise to particularise at present, as apart from the set of observations referred to on page 197, the number relating to each is low.

Coconut-shell Group.—Nothing could be more striking than the difference between a wooden and a steel water-butt, as regards their mosquito faunas. The one will contain *Stegomyia albopicta* and the other *S. sugens*, and in all my observations of two such water-butts in my own garden, I have never found one species invade the territory of the other. I think I have only once found the two species breeding together, this being in the rock pool described in my paper of 1921, a situation to which I have not succeeded in finding a parallel since the present investigation was begun. On that occasion the large amount of vegetable debris in the pool evidently introduced a factor appertaining to the tree-hole group, indicated by the presence of *Finlaya gubernatoris*, but the true rock-pool element was still dominant, as shown by the total of 81 per cent. of the emergences being species of this group.* As figure 2 shows, it is not possible to find *F. gubernatoris* without encountering conditions favourable to *Stegomyia albopicta*, the presence of which in this exceptional locality is thus accounted for, though not, of course, explained.

* *Finlaya trilineata*, as recorded in the original paper, is a misidentification. The species concerned is the subsequently described *F. macdougalli*, Edw., as noted by Barraud (1924).

Stegomyia albopicta, Skuse. In this we apparently encounter a species with tolerances equal to nearly all the extremes of variation possible in the three factors investigated. There is no question here of the records of extreme alkalinity (pH 9.2-9.6) being due to hyperoxygenation. These records are from "anti-formicas" still showing traces of the kerosene oil used as a larvicide, which had not been renewed sufficiently recently. Dr. Hacker has informed me of his as yet unpublished discovery that the spread of oil on water depends on the presence of an —OH group, and that pure kerosene will not spread, hence the very high alkalinities encountered in such circumstances as those under discussion are to be expected. On the acid side the species shows a range extending far beyond the possible bicarbonate limits, in circumstances where these compounds are almost certainly not present, the acidity being due to organic radicles formed from the juices of the receptacles.

In respect of solute tolerance, I am by no means convinced that I have yet found the limiting value. Oxygen figures are usually unobtainable, for the reason given in Section V. The observation with 6.34 mg. ‰ refers to a big volume of water in a wooden barrel, the sides of which were covered by a Cyanophyceous alga, probably a *Lyngbya*, and in many of the locations where the species is found the oxygen appears to be nil, the final stage of the Winkler process releasing no iodine.

Wide as these tolerances are thus shown to be, it is still probable that, in respect of pH at least, the species has an optimum. In the laboratory, as noted by Lamborn (1922, p. 8), it is often a perfect nuisance, contaminating breeding bowls containing other species. But, as Lamborn also points out in the same connection, though there may be numerous bowls exposed to its attentions, some may be selected day by day for oviposition to the neglect of others. The reason for this must be a water-factor, and for some months I kept a record of the pH in such contaminated bowls on the morning after oviposition was discovered, with a view to seeing whether any preferences were recognisable. To complete the record, this should have included observations of the pH of all other bowls that were available, but were not utilised, on each occasion. Unfortunately this was not done, but Table VII shows an apparent preference for considerable alkalinities. It should be mentioned that definitely acid water was probably seldom available, as almost any water will slowly turn alkaline in the laboratory, rising to high values of pH 8.0 and over, probably owing to loss of CO₂ and ammonia absorption from the room atmosphere, a fact which, I think, explains most of the mortality that always occurs in breeding bowls.

TABLE VII.

Stegomyia albopicta ovipositing in Laboratory Breeding Bowls.

	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	Remarks.
15.v.24 ...	—	—	—	—	—	—	—	—	2	
17.v.24 ...	—	—	—	—	—	—	—	3	—	
17.v.24 ...	—	—	—	—	—	—	—	3	—	
17.v.24 ...	—	—	—	—	—	—	—	—	2	
18.v.24 ...	—	—	—	—	—	—	—	16	—	
18.v.24 ...	—	31	—	—	—	—	15*	—	—	* Did not hatch.
20.v.24 ...	—	—	—	—	—	76	—	—	—	
23.v.24 ...	—	—	—	—	—	—	1	—	—	
1.x.24 ...	—	—	11	—	—	—	—	—	—	
24.i.25 ...	—	—	—	—	—	—	—	24	—	
24.i.25 ...	—	—	5	—	—	—	—	—	—	
21.ii.25 ...	—	—	65	—	—	—	—	—	—	
Average per oviposition	—	31	27	—	—	76	8	11.5	2	

A set of experiments was therefore commenced with a view to making a more exact test. Freshly hatched specimens of both sexes were caged, and after copulation and egg-maturation were offered water at varying pH values for oviposition. The experimental difficulties were considerable, as it was extremely difficult to keep constant the pH in the various bowls. Finally, water in quite small volumes was used, either placed in small bowls or in the depressions in a porcelain artist's palette, each collection being indicated by an indicator of suitable virage. Thus any change from the required value in any bowl was noticed at once, and corrected by a trace of very dilute HCl or KOH. The change, again, was nearly always towards alkalinity, and though it could be temporarily rectified by blowing expired air through the water, the colour of which at once commenced to change as bicarbonates were formed, the operation being stopped when the correct tint was again reached, the effect was quite evanescent. All the sulphon-phthalein indicators in quantities such as are used in pH work are non-toxic to larvae, as has been pointed out by Saunders (1923), but as it is well known that mosquitos have colour preferences, mainly in the blue region, it is possible that the addition of indicator to the experimental waters affected the results. The alkaline tints, with brom-thymol-blue, are increasingly blue, but there is no evidence that colour preference entered into the question none the less, for waters of the same pH coloured with different indicators, one giving red and the other blue tints at such a value, have been equally favoured or neglected.

The results of several experiments carried out as above are summarised in Table VIII. Here, again, we see what appears to be a preference for the alkaline region, though the results are far from being as definite as one could wish. But as the two sets of observations support one another, it must be supposed that *S. albopicta* really has a preference for oviposition in alkaline waters, although Table I, which includes only observations made in the field, does not confirm this to the same extent, for here the largest number of larval findings are all concentrated around neutrality.

Attempts to repeat this experiment with other species of mosquitos, with narrower toleration ranges than *S. albopicta* is shown to possess, have in every case failed.

Finlaya trilineata, Leic. Though closely associated with it, this is a much more specialised species than the foregoing one. The reason for this is that it is not found elsewhere than in coconut-shells, old tins, etc., avoiding the bamboo and tree-hole breeding-places equally favoured by *S. albopicta*, where far more varying admixtures of organic matters are possible than in mere artificial receptacles, which is confirmed by the much lower limit of the solute-tolerance range. I have indicated the species in figure 2 as found in water over a bottom layer of earth, rain-splashed into the breeding receptacles it favours, which usually seems to be the case.

Tree-hole Group.—The peculiar conditions governing this group were examined by Howlett,* who discovered that the tannin, which is probably always a constituent of such waters, had no attractive effect leading to oviposition by species of this group. Of the five species allocated to the group in figure 2 it has only been possible to obtain any considerable number of figures on two, *Finlaya greeni* and *Culex brevipalpis*, which unfortunately are less specialised in their tastes than the others, for both have been obtained on occasion from bamboos, and once, both together, from a snail-shell. Though the water of tree-holes in Europe is said to be always acid (MacGregor 1921, Wesenburg-Lund 1921), this is not my invariable experience in Ceylon, but more figures are required before anything definite can be suggested. Both the two species named above will tolerate high solute-concentrations. Though no

* Unpublished work, found among his notes when I held charge of his Section at the Agricultural Research Institute, Pusa, after his demise.

TABLE VIII.
Oviposition of *Stegomyia albopicta* at various *pH* values.

	2.8	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6
Expt. 1	—	—	—	—	—	—	—	—	—	2	3	—	7	—	—	44	3	60	—	—	—	—	—	—	—	—	—	—
Expt. 2	—	—	—	—	—	—	—	—	—	7	0	0	0	17	13	22	31	37	—	—	—	—	—	—	—	—	—	—
Expt. 3	0	11	—	—	0	74	—	0	1	—	39	0	39	—	71	—	20	—	7	—	108	58	18	0	—	20	—	—
Expt. 4	0	—	—	—	1	—	—	—	—	8	—	9	—	20	42	0	—	54	—	18	—	79	7	53	43	—	13	—
Totals ...	0	11	—	—	1	74	—	0	1	17	42	9	46	37	126	66	54	151	7	18	108	137	25	53	43	20	13	—
Average	0	11	—	—	0.5	74	—	0	1	5.7	14	3	15.3	18.5	42	22	18	50.3	7	18	108	68.5	12.5	26.5	43	20	13	—

Average=24.6.

Probable Error=±5.8.

A "—" in the column indicates that water of this *pH* was not available for composition.

oxygen observations have been made, the nature of the water in most of the collections that have yielded these two species, reeking as it frequently has of H_2S , would indicate that it could have contained little or no free oxygen.

Bamboo Group.—Whereas it has been shown that the tree-hole group may on occasion be found in bamboos, yet the reverse is seldom or never the case.

Rachionotomyia aranoides, Theo. Exclusively a bamboo breeder. I have only once found it elsewhere, in water at the leaf-bases of a pineapple, and have not, in several years, again so found it. It tolerates acidity up to the limit at pH 4.4, but its range into alkalinity appears to be low. The optimum is, as usual, around neutrality. In regard to solute-tolerance, it does not pass the natural-water limit of $C \times 10^6 = 1,000$. Its non-occurrence in very pure water of <100 is simply due to the fact that water in bamboos is never of so low a conductivity. It can tolerate entirely de-oxygenised water.

Culex uniformis, Theo. Not so strictly a bamboo breeder as the foregoing. I have found it once in a snail-shell, in a half coconut and in a tree-hole, and more than once in cacao pods, but in the latter the water conditions must approximate to those in freshly-cut bamboos. It apparently tolerates acidity very poorly, but will go to a high degree of alkalinity, probably caused in the extreme case by a bottom deposit of limestone dust, the bamboo in question being examined during very dusty weather on the side of a road metalled with this material. The species has a high solute-tolerance, but I think the top figure more truly indicates the upper limit than it does in the case of *S. albopicta*.

Culex minor, Leic. I have included this species in this group, as it is very closely allied morphologically to the previous one (neither the adult female nor the larva can be differentiated), whilst it has practically a 100 per cent. association-value with it. None the less, on few of the occasions on which it has been bred has the habitat been a bamboo, but nearly always one of the exceptional localities recorded for *C. uniformis*. Too little is known of it to particularise as to its tolerances at present.

Foul-water Group.—As figure 2 indicates, this can be again subdivided into containers with large and small volumes of water, though the divisions over-lap, as one would expect.

Culicomyia pallidothorax, Theo. This species is far less tolerant of organic pollution than the other three in this group; it may, in fact, separate from them as a result of further experience regarding it. In any case, it forms the annectant link to *Stegomyia albopicta* as found in wooden water-butts. The data on it at present are, however, too few for anything definite to be laid down as to its tolerances.

Culex fatigans, Wied. Since the capture of the single female in March 1920 recorded in my paper of 1921, this species was not again seen at my station until it appeared in the water-butt described in Section V, Table V. Elsewhere it has once been met with in a pool, practically a cess-pool, beneath a goat-shed built across a ravine. Thus, curiously, one of the commonest species of mosquitos in the world is in my experience too rare for anything to be said concerning its tolerances. It must be a very unusual event for the species to find itself in water with high, let alone supersaturated, oxygen content, for such foul waters as it frequents must contain little or no free oxygen. The stimulus which called it up to breed in the circumstances detailed in Section V must have been the drowned animals at the bottom of the water, and not the green algal growth responsible for the high oxygen content, which in all probability was confined to the upper water layers. None the less, the very low conductivity does not indicate any considerable amount of amino-substances in solution. As there was about two feet of water in the barrel I do not think that any of the species found were able to feed at the bottom.

Armigeres obturbans, Wlk. Pre-eminently the species of foul liquids. The largest and best-grown specimens I have ever seen were from a latrine sump-pit, and

were breeding in almost pure urine. As regards pH, it seems able to tolerate anything except the highest alkalinities. I have taken it in a tin containing fermenting fowl-food reeking of acetic acid at 4.4. In regard to conductivity, it has a higher tolerance than any other species, save its immediate relative next to be considered, and is, in fact, not found in large numbers in the weaker solutions. At the highest concentration yet found, $C \times 10^6 = 7,534$, no less than 119 larvae were found in a coconut-shell in a rubbish pit, the contents of which were of a pea-soup-like consistency, with Phorid larvae also present, and the surface covered with Collembola.

In connection with this species some interesting data were obtained in the course of repeating the rice-water experiment described by Lamborn on page 11 of his paper of 1922. When carried out here the *Culex* (probably *fatigans*) which in Malaya found the medium so favourable was replaced by *Armigeres obturbans*, the only occasion on which I have found this species attracted to the laboratory for oviposition.

The rice was boiled and strained to remove the larger particles, after which it was divided into two portions. One was exposed as it was, a cloudy mucilage-like mass, the other was filtered hot, but even this, on standing, soon deposited a bottom layer of starch. The filtered portion had a conductivity of 544. Both portions gave a strong starch reaction with iodine. The two lots were exposed in large glass tumblers by a window catching sun during most of the day. Table IX shows the subsequent course of events.

TABLE IX.

Lamborn's Rice-water Experiment.

Date.	pH	$C \times 10^6$	Unfiltered.	Adults.	pH	$C \times 10^6$	Filtered.	Adults.
6.xii.24	5.6	—			6.1	544		
8.xii.	6.2	—	No odour.	<i>A. obturbans</i>	6.4	—	Faint odour. 11 eggs laid	<i>A. obturbans</i>
9.xii.	4.4	—	Starch reaction +		5.6	—	Starch reaction +	
10.xii.	5.0	—	Fermenting. No odour.		5.0	—	No odour. Not fermenting.	
11.xii.	4.4	—	do. do.		4.4	—	do. do.	
12.xii.	4.4	—			4.4	—	6 larvae hatched. In trouble with surface scum.	
13.xii.	4.4	—	Sour odour. 36 eggs laid.	—	4.4	—	Larvae growing	—
14.xii.	4.4	—	do. Starch reaction—	—	4.4	—	Starch reaction—	—
15.xii.	4.4	—	Very sour, yeasty odour. 17 eggs laid.	—	4.4	—	Slight odour, sour, yeasty.	—
19.xii.	4.4	—	Very sour. Young larvae entangled in pellicle.	—	4.4	—	Sour odour. A green alga marginally.	—
21.xii.	4.4	—	A mould growing. Thickly plastered with eggs.	—	4.4	—	Scum clearing. Thickly plastered with eggs.	—
22.xii.	4.4	—	<i>Bac. prodigiosus</i> . Scum clearing.	—	4.4	—	<i>Bac. prodigiosus</i> .	—
23.xii.	4.4	—	Smell of lactic acid.	—	5.2	—	Full of newly-hatched larvae.	—
24.xii.	4.4	—		—	6.3	—	Water green. <i>Pleurococcus</i> sp.	—
25.xii.	4.4	—		—	6.7	—		—
26.xii.	4.4	—		—	7.0	—		4
31.xii.	4.4	—		10	7.0	—		—
2.i.25	4.4	—	Bottom deposit and surface film all eaten off.	—	6.8	—	Film all eaten, and most of bottom deposit	—
4.i.	6.0	—	No odour.	10	7.0	—	No odour. Liquid brownish green.	—
5.i.	7.0	—		3	7.2	—	Green alga gone.	—
6.i.	7.0	—		—	7.8	—		—
7.i.	7.0	—		13	7.2	—		—

TABLE IX—continued.
Lamborn's Rice-water Experiment—continued.

Date.	pH	C × 10 ⁶	Unfiltered.	Adults.	pH	C × 10 ⁶	Filtered.	Adults.
8.i.25	7.0	—		—	7.1	—		—
9.i.	7.0	—		10	7.2	—		3
12.i.	6.6	—		16	7.2	—		11
14.i.	6.6	—		4	7.1	—		7
16.i.	6.4	—	Just hatched larvae present.	16	7.4	—	Liquid brownish green. Just hatched larvae present.	4
18.i.	6.0	—	Shaken up before sampling	5	7.3	—	7.2 before, 7.4 after shaking up.	1
19.i.	6.2	—		—	7.3	—		1
21.i.	6.4	—		3	7.3	—		—
24.i.	6.2	—		—	7.4	—		2
26.i.	6.4	—		—	7.2	—		—
28.i.	6.8	—		3	7.4	—		2
30.i.	7.0	—		5	7.8	—		2
3.ii.	7.2	—		5	7.4	—		3
5.ii.	7.0	—		4	8.0	—		2
7.ii.	7.0	—		5	7.3	1775	Reduced to 25% original volume. Last larva pupated.	
10.ii.	7.0	—		9	—	—		1
12.ii.	7.0	—		9	—	—		1
14.ii.	7.0	—		9	—	—		44
16.ii.	7.0	—		2	—	—		<i>S. albopicta</i>
18.ii.	7.0	1991	Reduced to 25% original volume. Refilled to original volume with distilled water.	5	—	—	Refilled to original volume with distilled water.	
19.ii.	6.9	358		4	7.4	482		
21.ii.	7.0	—		3	7.4	—	65 eggs laid.	—
23.ii.	7.0	—		2	7.6	—		—
25.ii.	7.0	—		—	7.6	—		—
27.ii.	7.0	—		2	7.6	—	Larvae growing slowly.	—
1.iii.	7.0	—		4	7.8	—		—
3.iii.	7.2	—		3	7.8	—		—
5.iii.	7.2	—		1	7.8	—		—
7.iii.	7.2	—		2	7.7	—		—
9.iii.	6.9	—		—	7.4	—		—
11.iii.	7.1	—		2	7.4	—		—
13.iii.	7.2	—		1	7.5	—		—
15.iii.	7.3	—		5	7.4	—		2
18.iii.	7.3	—		4	7.6	—		1
20.iii.	7.3	—		6	8.0	—		1
24.iii.	7.4	—		3	7.8	—		—
27.iii.	7.6	—		1	7.7	—		1
29.iii.	7.4	—		3	7.7	—		—
2.iv.	7.6	—		2	8.2	—		—
3.iv.	7.4	—		1	7.6	—		—
15.iv.	7.8	—		3	8.4	—		3*
				198				8

* Larvae still immature.

It will be seen that eggs were not laid on the unfiltered portion until it had attained its maximum acidity. The filtered portion was much more quickly infected. Fermentation was apparently lactic, for a very strong odour of this developed in

both lots. The life of the larvae during the earlier stages of the experiment depended on lacunae in the surface pellicle, which they were not, when young, able to penetrate for themselves (the eggs were all laid around the margins of the vessel and not on the liquid itself). However, the larvae browsed this surface scum off before starting to eat the lower layers of deposit. The lacunae were caused by the taking of samples for pH purposes. *Bacillus prodigiosus* appeared in both lots, but more so in the filtered one, where alone a green alga succeeded in establishing itself, though both lots were apparently infected, as signs of green growth were seen for a short while in the unfiltered portion also. The alga was a species of *Pleurococcus*, and whilst it flourished the water was quite green. The rise in pH due to its presence was noticeable. The organism concerned in the subsequently occurring rise in pH in the unfiltered portion was not isolated. It did not show green in the water.

About ten weeks after the commencement of the experiment the volume in both lots had been reduced by evaporation and sampling (very small volumes were used for this, by the drop method) to about 25 per cent. of its original extent, with a corresponding increase in conductivity. The unfiltered portion was too thick at the commencement of the experiment for measurement, but a control put up at the same time with toluene (though when this had evaporated some mould appeared on the surface) had a conductivity towards the end of the experiment, when by slow sedimentation the body of the liquid had become quite clear, of 581, after making up to original volume with distilled water, which may approximately represent the conductivity of the unfiltered portion at the start of the experiment. The reduction of 223 in the unfiltered and of 62 in the filtered portion represents the material removed in producing 150 and 44 adult *Armigeres obturbans* respectively, or a reduction of 1.49 and 1.41×10^6 per adult respectively. Comparatively few of the eggs laid in both lots produced adults, but the cannibalistic propensities of this species are well known, and most of the larvae only served to render, in themselves, the food material more available to their stronger brethren. The family of *Stegomyia albopicta* that reared itself in the filtered portion after this was refilled was slow in growth and produced the smallest adults of this species that I have seen. Evidently there was practically no food material left in the liquid, or in the bottom débris, consisting mainly of the faeces of the *Armigeres* broods. The development of the latter in the unfiltered lot proceeded very slowly towards the end of the experiment also, the larvae seeming to root fruitlessly in the bottom débris for food. The size of the adults was also greatly reduced latterly.

From these results it is easy to understand why Lamborn failed to secure hatching of *Anopheles vagus* ova on acid rice water. The pH of this at the time he experimented ("boiled a few days previously") must have been 4.4. Doubtless newly-hatched larvae are even more susceptible to incorrect pH than are more mature ones, and this water must have been two whole Sørensen degrees outside the limiting value for the species. Two months after, when further ova of *A. vagus* were successfully tested on the water, its reaction, judging from the condition of the water in my experiment after that period, must have been about neutral, but probably food material was low, thus explaining the failure of the larvae to complete their development.

Though in my case *S. albopicta* did not appear in the medium until it was clear of *Armigeres obturbans* (or at least no larvae reached maturity), this is explained by the predatory habits of the latter species, and Lamborn's record of their successful hatching at pH 4.4 is within the range of the species. The *Culex* larvae would not share the predatory habits of the *Armigeres*.

Armigeres aureolineatus, Leic. This species has a 100 per cent. association with the previous one. It has not been found in such acid or such weak media as the latter, but being rarer there are not so many data on it. The upper limits of pH and solute-tolerance are identical. Whether it is really of more restricted lower ranges only accumulation of further data can confirm or disprove.

Predators.—The two species here included do not belong to any group, being found, in suitable circumstances, in association with many of them.

Megarhinus splendens, Wied. Found in association with the tree-hole and bamboo groups. Though it will, exceptionally, tolerate high alkalinity, it will apparently not suffer any great amount of acidity, whilst it requires solutions of a rather restricted, though high, range of concentration. This explains why it is seldom found with the rock-pool group. Paiva (1912) records it as commonly occurring in rain-filled earthen pots, where it was presumably mainly preying on *Stegomyia albopicta* and *fasciata*, though the point is not specifically noted; but I have not myself found it in such situations.

Lutzia fuscana, Wied. I have included all the specimens belonging to this genus under one species, as Edwards (1922) is inclined to do, though there are truly some distinct varieties. Of these, the distinctions so intergrade that further determination is very doubtful and difficult, whilst the larvae are all exactly similar, as pointed out by Barraud (1924A). None the less, either the species is one of the few appertaining to both natural (standing) and artificial waters, or else the forms found in these two sets of conditions are truly distinct. I have included them together as one species, wherever found. This, in natural waters, usually preys on the banded-proboscis group of *Culex* and species associated with these; in artificial waters, where it is much rarer, I have found it associated with *Armigeres obturbans* and *Culicomyia pallidothorax* only. Apparently the pH range is very restricted, 6.6–7.2 only, for of the two higher records, one (at 8.6) was in hyperoxygenated water with *Volvox*, as described under *Culex vishnui*, while in the other (at 8.0, with less than 5 mg. oxygen per litre) the single larva found was attacked by ectoparasitic Protozoa. The solute-tolerance is narrow, with an apparent optimum at the same value (<500) as the standing-water species of *Culex*, whilst the two oxygen values obtained show very low contents.

VIII. Algal Distribution and the Food of Larvae.

Considering now the toleration-limits and optima indicated in Section VII for the various species, it is necessary to enquire how these act in controlling the presence of larvae. It appears doubtful if varying water composition acts solely by influencing the metabolism of the animals themselves. As an instance of such direct action, it would appear likely that, as, according to the authorities quoted by Wesenbourg-Lund (1921, p. 15), expiration takes places *via* the body-walls, water already saturated with CO₂ would interfere with respiratory exchange, and so at times CO₂-pressure would be the dominant factor. In a recent paper Chidester (1924) writes of CO₂ pressure and pH as if the two terms were synonymous. This is hardly correct. CO₂-pressure is undoubtedly a prime factor in the causation of hydrogen-ion concentration; none the less, as shown at the end of Section III, the total concentration value is due to more than dissolved gases alone, and until the various factors contributory to a pH result are separately evaluated, the measurement of the resulting concentration will not yield its full quota of information. It is hoped to proceed to the investigation of this point in a subsequent paper.

However, it may be doubted if a mosquito larva, clothed in a more or less tough chitinous cuticle and with direct access to atmospheric air, is nearly so susceptible to changes in water composition as many of the more strictly aquatic organisms related to it bionomically, as food or as enemies, especially the former, and it may well be that the tolerance and optima of Section VII are in reality not solely those of the larvae themselves, but, in large part at least, those of their food organisms; and it would appear essential to further progress that studies on the food of the various species should be made, for it seems that singularly little is really known on the matter.

According to Wesenbug-Lund (1921) surface-feeding species live on plankton and suspended detritus. The *Culex* group in this category use the antennal fans as a strainer to block out too large particles from the mouth-parts. The bottom-feeding species live on organisms and detritus, upon decaying leaves and Diatom-coverings of plants. According to this writer there is an indiscriminate capture of food particles, but a rejection of undesirable material through a cleft between the maxillae. If I understand him aright, this process is common to both surface and bottom feeders.

Lamborn (1922) was attracted to this side of the question through his success in feeding several Anophelines on *Euglena*. He apparently commenced this part of his investigation with the conviction that algae form the entire food of the larvae for he makes no reference to detritus or to organisms other than algal, as does Wesenbug-Lund. From this, he goes on to give a collection of very interesting and extremely suggestive quotations from West and from Fritsch (1907) with a view to showing that mosquito distribution is bound up with that of algae; but the consequences of this enquiry can only be to move the problem one stage further back, and to become as involved in the maze of unknown factors governing algal distribution as we are at present in those controlling mosquitoes. Behind both, and probably controlling both, are the ultimate chemico-physical factors, with a few of which the present paper attempts to deal. Very generally, Fritsch indicates some possible causes for algal distribution, but his investigations do not seem to have been completed by even partial water analyses. In this respect an earlier paper of the same author's (Fritsch, 1906) contains many interesting suggestions having a possible bearing on mosquito-prevalence.

During several years' mosquito work, including the present investigation, notes have been kept of the various algae met with. Specific identification has not often been possible, but such information as is available is recorded here, mainly with a view to showing that by itself this line of enquiry would have proved futile. The information obtained may, however, one day fall into place, for in a problem so far from solution as natural mosquito control still is, everything that can be put on record may yet possibly be of value. One must work in the spirit which is discussed by Fiske (1920) in his introductory paragraph.

CYANOPHYCEAE.

Aphanolthe (?) pallida has been found on freshly levelled mud in a rice-field ready for sowing. No larvae were found associated with it. *Chroococcus* and *Synochococcus* spp. were found on *Gonatonema* in a drain outflowing from a spring-fed well (pH 6.4). No larvae were found, but fish and Odonata were numerous.

Phormidium tenue was found on a sunken tamarind fruit in a stream. With it were associated *A. maculatus* and *A. listoni*, and these species were not found away from the alga. They had not been found in this stream for several months previously, nor were they found again for months subsequently.

Oscillatoria. A dense mass of *O. tenuis* with a little *O. princeps* was found in a spring (pH 7.0) mixed with various Diatoms. No larvae were present. Species of this genus have several times been found with *Spirogyra*; once in a rice-field (pH 7.1, C=443, oxygen 7.24 mg. %_{cc}), but the only mosquito was *C. bitaeniorhynchus*, which is definitely attached to the higher alga; and more than once they have been found in a stream of approximately neutral pH, but the various mosquitoes found on such occasions were probably more interested in the *Spirogyra* and its associated Diatoms than in the *Oscillatoria*, which was not a main constituent of the association. According to Fritsch (1906) the abundance of this genus and certain other Cyanophyceae is due to an increase of organic substances in solution.

Lyngbya. The sides of a wooden barrel serving as a water-butt in my garden were lined with a species of this genus for a long time. Periodical oiling had no

effect on it, but cutting down the barrel to water-level, and so admitting strong sunlight to the water-holding portion, destroyed most of the growth. The pH varied from 7.1 to 7.5, conductivity from 262-300, and the single oxygen measurement made gave 6.34 mg. $\%_{\text{O}_2}$. *Stegomyia albopicta* always invaded the barrel between oilings, and seemed to feed on the algal surface.

Nostochopsis. On one occasion I found the boulders in a swift-running stream thickly coated with this (pH 6.0, C=99). Larvae were present, but were not associated with this alga, but only with a *Spirogyra*.

Hapalosiphon laminosus. I am quite certain that larvae are not associated with this species, which at times forms a thick fringing mass to tanks. I have found it in a stone-lined well (pH 6.2-6.4, C=200) that in 12 monthly examinations never produced a single larva, but my chief experience with the species has been in an impounded spring forming a miniature tank the ecological changes in which are fully described in Section X. Throughout 18 months' examination at weekly intervals the species has steadily flourished, the pH varying from 6.4 to 6.8, the conductivity from 148 to 389, and the oxygen-content from 1.33 to 4.59 mg. per litre; but whenever larvae have been found in the tank, it has been possible to associate them definitely with various other algae, to the complete exclusion of *Hapalosiphon* as a source of food. Miss Rich, who determined the species for me, notes that my specimens differ from the general condition of the species in not being hardened with calcium carbonate. Considering that the hardness of the water shows that the carbonate is abundant in it, this is not easily understood, but is probably due to the excess of carbonic acid in the spring water.

Calothrix. I have twice found what appears to be small portions of a species of this genus in centrifuged plankton. On the first occasion larvae were not found (pH 7.3, C=630, oxygen 7.58 mg. $\%_{\text{O}_2}$). On the second occasion a solitary *Dixa zeylanica* was present (pH 7.0, C=351, oxygen 6.71 mg. $\%_{\text{O}_2}$). On one occasion I have found this organism in some numbers in the gut contents of *A. maculatus* (*vide infra*).

BACILLARIACEAE.

Whilst I share the opinion of Wesenburg-Lund that Diatoms form an important part of larval food it is not by any means easy to prove this. These organisms are so universally distributed in fresh water that they are as commonly found where larvae are absent as where they are present. Gut contents will be discussed subsequently, but it might be mentioned that there is no more likely spot to find the stream-breeding *A. maculatus* and *A. listoni* than among the roots of *Mikania scandens*, which so often trail in such waters, and these roots are invariably thickly coated with Naviculaceae and *Fragilaria*. Removal of the roots from the water will effect a great reduction in the number of larvae, but as this exposes them not only to their enemies, but also to the full current, the reduction cannot be properly attributed to the deprivation of Diatom food only.

Melosira. Found once with numerous Naviculaceae on filaments of *Oedogonium* (pH 6.6, oxygen 2.80 mg. $\%_{\text{O}_2}$). Larvae were absent.

Navicula pupula. The species formed the main constituent of a thick mass of Diatoms in a bubbling scum in an irrigation channel. Though larvae were plentiful elsewhere in the channel, none were found among this patch.

Pinnularia lata var. *costata*. This formed one of the minor constituents of the scum referred to under the previous species.

Cymbella ventricosa var. *ovata* and *Cymbella* sp. were other constituents of this scum.

Gomphonema. A species of this genus was also included in the above-mentioned scum. A species has also been found attached to *Oedogonium* in the presence of *Spirogyra*. *A. listoni*, *A. barbirostris*, *C. mimulus* and *C. bilaeniorhynchus* were present, but only the last was associated with the algal mass, and had its usual connection with the *Spirogyra*.

Achnanthes brevipes. Found attached to *Oedogonium*. Larvae were present in the water, but were not particularly attached to the algal filaments, preferring the vicinity of *Pistia stratiotes*.

Achnanthes spp. One species has been found attached to *Gonatonema* (pH 6.6, oxygen 3.07 mg. %/‰); larvae were absent. Another species, of the subgenus *Microneis*, found attached to *Oedogonium*, seemed to be the food of *A. listoni*, *A. barbirostris* and *C. mimulus*.

Nitzschia spp. Found mixed with *Oscillatoria* spp. in a spring (pH 7.0) from which larvae were absent.

Surirella. Found in company with the previous genus as just described.

Synedra ulna var. *oxyrhynchus*. This formed one of the minor contents of the scum described under *Navicula pupula*.

Synedra vitrea. Found on *Oedogonium* with *Achnanthes* (*Microneis*) sp., as recorded under the latter.

Synedra sp. Found mixed with other Diatoms and *Oscillatoria* in a spring containing no larvae (pH 7.0).

Fragilaria. Found on *Mikania scandens* roots, where *A. maculatus*, *A. listoni* and *D. zeylanica* were feeding (pH 7.0, C=738, oxygen 3.36 mg. %/‰).

Epithemia. Found attached to *Oedogonium* in the circumstances detailed under *Gomphonema*.

Eunotia pectinalis. Found attached to *Oedogonium* in the circumstance recorded for *Achnanthes* (*Microneis*) sp. Both vars. *minor* and *media* were present. Var. *media* was also found on *Oedogonium* as recorded for *Gomphonema*.

Tryblionella punctata. Another minor constituent of the *Navicula*-scum from which larvae were absent.

CHLOROPHYCEAE.

Desmidiaceae.

Closterium ehrenbergi. Found around *Oedogonium* in association with which *A. listoni*, *A. barbirostris* and *C. mimulus* were feeding. On another occasion it was found literally swarming round the subaqueous stems of *Limnophila sessiliflora* (pH 6.6, C=320, oxygen 3.64 mg. %/‰). None was found in the surface water centrifuged for plankton, and on this occasion it seemed to be living too deep to serve as at least an Anopheline food.

Closterium lineatum. Found around *Oedogonium* attached to *Vandellia pedunculata* in a swampy, uncultivated area in a rice-field. *A. listoni* was present in large numbers.

Closterium spp. Found with *Volvox* in centrifuged plankton from a drain, pH 6.6; oxygen 1.60 mg. %/‰. No larvae present. Found on another occasion swarming round *Spirogyra* and *Oedogonium* in a jungle pool (pH 8.6, C=312). The algal mass was in active photosynthesis, and the water was all bubbles. *A. barbirostris* and *C. mimulus* were numerous.

Cosmarium. A species of this genus has been found once as a plankton constituent in a stream among *Mikania scandens* roots as recorded under *Fragilaria*. Three species of mosquitos were present.

ZYGEMACEAE.

Spirogyra. On no occasion has it been possible to determine species in this genus. The filaments have invariably proved sterile. That the genus and its associated organisms are a favourite food of mosquito larvae the following records show. As noted in Section VII, *Culex bitaeniorhynchus* is absolutely attached to it, though at times the alga may be found without the mosquito.

TABLE X.
Spirogyra.—*Water and Mosquito Associations.*

Locality and Month.		pH	C × 10 ⁶	O ₂ mg. %	<i>A. barbirostris</i> .	<i>A. sinensis</i> .	<i>A. maculatus</i> .	<i>A. leucosphyrus</i> .	<i>A. listoni</i> .	<i>A. jonesi</i> .	<i>A. vagus</i> .	<i>U. campestris</i> .	<i>C. minutus</i> .	<i>C. minutissimus</i> .	<i>C. bitaeniorhynchus</i> .	Remarks.
Tank.	March ...	6.7	—	—	+										+	No larvae present.
"	April ...	6.6	—	—											+	
"	April ...	6.6	—	—											+	
"	April ...	6.6	—	—											+	
"	May ...	6.5	—	—											+	
"	May ...	6.5	—	—						+					+	Nil. Alga unhealthy
"	May ...	6.4	—	—	+										+	
Irrigation Channel.	May ...	7.0	—	—	+									+	+	
"	June ...	7.2	—	1.80	+				+						+	
"	June ...	6.8	—	—											+	
"	June ...	7.2	—	1.07	+		+							+	+	Nil. NH ₃ 1.2 p.p.m.
"	August ...	7.0	372	5.20											+	
"	August ...	7.0	398	5.80											+	
"	September	6.9	356	5.45			+		+						+	
Stream.	May ...	7.5	—	—					+						+	
Drain.	July ...	6.6	—	1.60											+	Nil. Irrigation Channel sp.
Rice Field.	February	7.0	372	2.58		+									+	Nil. Irrigation Channel sp.
"	February	7.0	429	4.31											+	
"	February	6.8	394	3.47											+	
"	January	7.1	443	7.24											+	
"	May ...	8.0	—	—											+	
"	June ...	7.2	484	4.54											+	Oxygen super-saturated.
Stream.	April ...	7.1	—	—	+		+		+		+	+	+		+	
"	April ...	7.0	—	—			+		+			+			+	
"	April ...	7.0	—	—			+		+			+			+	
"	May ...	7.0	—	—			+		+			+			+	
"	June ...	7.3	—	—					+					+	+	Oxygen super-saturated.
Puddle.	May ...	7.2	—	—							+				+	
Stream.	July ...	6.8	110	—											+	
Drain.	June ...	6.8	—	—			+								+	
Stream.	July ...	6.2	—	—	+		+								+	
"	August ...	6.0	99	—			+	+							+	Oxygen super-saturated.
Swamp.	September	8.0	191	—											+	
Pool.	January	8.6	312	—	+								+		+	Oxygen super-saturated.
River.	March ...	7.6	191	—											+	

Thus, out of 35 records, only 4 have failed to show the presence of mosquito larvae in company with the alga, or 88 per cent. positive.

Culex bitaeniorhynchus has been found 23 times in 31 positive cases, or 74 per cent.

Though it has been impossible to determine species in this genus, I think that there is little doubt but that several have been encountered. The usual species in rice-fields is of a blackish green, quite different from that of running streams; whilst the species found in the pool with a pH of 8.6 had the chloroplasts very faint and comparatively colourless, with the pyrenoids standing out distinct in their spiral arrangement. But until the various species are taken in definitely determinable form I am unable to show evidence that they affect water of different pH average-values, which I think is the case. None the less, the fact clearly emerges that the genus as a whole is not found in water of a high alkalinity, seeming to prefer water with a distinct acid reaction.

It would also appear that the genus only flourishes during certain months of the year, with its maximum abundance in May. This month, as Watson (1921) has shown, is that in which *maculatus*-caused malaria is at its height in Malaya (which is also the case in Ceylon), and it is significant that the algal and Anopheline maxima coincide. The underlying reason for the algal maximum is still to seek, but when discovered it would seem legitimate to hope that it will have an epidemiological bearing of the highest significance.

Mougeotia. Only found once, in company with *Spirogyra* (pH 6.8, C=110), and *Culex bitaeniorhynchus* was the only mosquito present.

Gonatonema. Found in a drain running out from a spring-fed well (pH 6.8) mixed with various Cyanophyceae. Larvae were absent, but fish and Odonata were numerous. Also found in standing water (though this had been running a week previously and had only just been reduced by drought to stagnation) in a drain at pH 6.6, oxygen 3.07 mg. / ∞ . Larvae were absent.

PROTOCOCCALES.

Chlamydomonas. Forms apparently belonging to this genus have been found twice in the same locality, a drain. On the first occasion the water was stagnant (pH 6.8, C=266, oxygen 2.53 mg. / ∞), and larvae were absent. On the second occasion the water was running (pH 6.7, C=224, oxygen 7.50 mg. / ∞), and *A. maculatus* and *A. aitkeni* were present.

Gonium. The whole of the records on the only species of this genus encountered are given in Table V in Section V. It is evidently a favoured food of *A. maculatus*, though I imagine rarely available to it, as the Volvocales are seldom if ever found in the swiftly running water favoured by this mosquito.

Volvox. Found in two jungle pools where it caused the very high pH of 8.6 by photosynthesis; conductivities 210 and 470 respectively. A pool near by of similar type but without the *Volvox* was at pH 7.2 only. The first of the pools contained *C. vishnui* with *L. fuscana* predatory, the second contained *A. sinensis*, *C. vishnui* and *C. tritaeniorhynchus*, whilst the third, without the *Volvox*, contained *C. tritaeniorhynchus* only.

I have also found what appears to be a different species, of smaller size, in a drain with standing water (pH 6.6, oxygen 1.60 mg. / ∞ , ammonia 1.2 p.p.m.). In addition to *Volvox*, which is evidently, from the former observation, a favoured food, *Spirogyra* and *Closterium* were present, but though Chironomids abounded, no mosquito larvae were found. Evidently the high ammonia content was inhibitory.

Oocystis. Found once only as a constituent of the plankton in a stream (pH 7.2, C=680, oxygen 11.0 mg. / ∞). The exceptionally high oxygen content,

which had risen from 2.67 mg. % in the week previous, and fell to 7.58 mg. % a fortnight later, can only have been due to the transitory appearance of this organism and the *Ulothrix* which appeared at the same time. Larvae were absent.

CONFERVALES.

Ulothrix. Found once with *Oocystis* as related above.

Cladophora. I have twice found a species of this genus growing on a floating fallen cacao pod in a tank from which, on both occasions, larvae had been absent for weeks previously; but in connection with each finding larvae were obtained, on the first occasion a single *A. maculatus*, on the second one specimen each of *A. maculatus* and *A. listoni*, on both occasions in the same dip of the ladle as lifted the cacao pod. The pH was 6.5–6.6, C=239–359, oxygen 5.64–3.87 mg. %. There is thus strong evidence of this alga furnishing a preferred food for Anophelines. According to Fritsch (1906, 1907), it is rare in the Tropics, demanding a higher oxygen content than such waters usually show, and it is further stated to carry a heavy epiphytic Diatom-flora.

STEPHANOKONTAE.

Oedogonium. Unfortunately all my takings have proved sterile, thus in this genus also specific determinations have been impossible. More than any other filamentous alga this genus seems to have epiphytic Diatoms, as may be seen from the frequent references to it in the paragraphs dealing with the latter group. Its neighbourhood is not, however, by any means a generally favoured feeding locality. Its replacement of *Spirogyra* in a tank for three months coincided with complete and immediate cessation of mosquito breeding. During the period it flourished pH varied from 6.4–6.6 and oxygen from 1.33 to 3.80 mg. %, but in the absence of specific determinations it is useless to attempt to indicate the tolerances of so widespread and specifically numerous a genus.

A point which may explain the reason why larvae are seldom associated with this genus of algae is that it is, in a sense, parasitic on them. I do not think that there is ever any question of it actually feeding on the tissues of the larvae, but the presence of attached filaments of the alga hampers the movements of the larva, and alters its hydrostatic balance, both tending to render it an easy prey to enemies. Usually larvae on which such filaments are found are unhealthy, and frequently carry ectoparasitic Protozoa as well. Nicholls (1912) was the first to draw attention to this phenomenon, in the Neotropical *Anopheles argyrotarsis*, R.-D. I have observed it myself in *A. listoni*, in a rice-field at pH 7.5, C=359, oxygen 6.95 mg. %, where in any case the mosquito must have been somewhat out of its element. Both Prof. West, to whom Nicholls' specimens were submitted, and Prof. Ball, who examined mine, came to the same conclusion, that the zoospores had simply found the larvae a convenient place for attachment and germination; but I think that healthy larvae thus attacked would usually succeed in clearing themselves, and that the effect is a secondary one. None the less, it can well be imagined that larvae would avoid the vicinity of an alga with such, for them, unpleasant habits.

Bulbochaete. A three-rayed organism, probably a dwarf male form of a species of this genus, is sometimes found associated with *A. maculatus*, and though it is obvious that it is not a factor in the distribution of this species, as the following table indicates, yet it will be shown later that, when available, it is a favoured food. Curiously, I have never succeeded in finding the filamentous form of the alga, but only the microscopic dwarf males in the centrifuged plankton.

Chaetophora. Found once in a channel with just moving water, leading from an irrigation tank (pH 7.2). *A. listoni* and *A. barbirostris* were present.

TABLE XI.
The Associations of *Bulbochaete* sp.

pH	Residual pH	C $\times 10^6$	O ₂ mg./l.	Larvae found.
6.8	—	222	7.07	<i>A. maculatus</i> , <i>C. minutissimus</i> .
6.4	6.7	232	3.27	Nil.
6.5	7.3	252	4.27	Nil.
6.4	6.9	211	5.47	Nil.
7.0	7.4	335	7.53	Nil.
7.1	7.8	474	4.50	<i>A. maculatus</i> .
6.7	7.4	224	7.50	<i>A. maculatus</i> , <i>A. aitheni</i> .
6.4	7.0	241	3.55	<i>A. maculatus</i> , <i>A. listoni</i> , <i>A. aitheni</i> , <i>C. minutissimus</i> , <i>C. castrensis</i> , <i>U. campestris</i> .

CHARACEAE.

Nitella mucronata. Found in a tank on frequent occasions (pH 6.5–6.6, C=200–389, oxygen 2.91–5.64 mg. /₁₀₀). It is not, however, generally a surface-dwelling genus, as pointed out by Schimper (1903), though the locality in which alone I have found it does not permit of its living at such depths as Schimper indicates. Thus it can generally have little to do with the feeding habits of mosquito larvae.

Chara zeylanica. Found once in masses in a big, shallow pool, about 12 inches deep, behind the mangrove zone at Trincomali. Though Odonata larvae were numerous, there were, of mosquitos, only a very few *Culex vishnui* present (pH 7.6, C=1,043). The high conductivity indicates a certain amount of salinity. A very little of the same species of alga was found near by in a drain (pH 8.1; C=11,191, nearly 33 per cent. salinity), but here larvae were more numerous, and *C. vishnui* was joined, as would be expected, by *C. sitiens*. The last situation was in all respects too abnormal to permit of any generally applicable conclusions being drawn.

Having now discussed in detail the algae found, it is possible to make a list of those forms concerning which there seems to be some evidence that they are favoured foods of mosquito larvae. This is given in Table XII. It will be observed that 80 per cent. of the species belong to the natural-water group, and of these half are Anophelines. In other words, Anophelines are to a far greater extent feeders on algae than are the rest of the CULICIDAE.

But if the limits given for the tolerances of various algae are even approximately true, then it will be seen that these are much narrower than the limits of the species that feed on them, which must, therefore, find other food materials when living beyond these limits. It is suggestive that the algal limits seem to coincide very roughly with what have been shown in Section VII to be the optimum conditions for most of the species listed in Table XII. It is extremely probable that algal tolerations are much narrower than those of mosquitos, but the determination of the former is a problem which the writer feels can only be undertaken by a botanist familiar with the species individually. In all ecological work an adequate systematic knowledge is a pre-requisite, and an entomologist cannot hope to have this in a Science other than his own.

Having thus connected certain mosquitos with certain algae ecologically, it remains to discuss such further evidence as is available as to whether the latter are really fed on by the former. Lamborn (1922) found that he could learn little on this point from the examination of the gut contents, owing to the fragmentary condition of the contained organisms, but the present writer has met with slightly greater success.

The feeding of *Anopheles maculatus* has been watched under a binocular microscope on several occasions. When placed with *Spirogyra* it nibbles the filaments from an end, readily consuming pieces of its own length. Lamborn (1922), who records a similar observation, succeeded in breeding the species to maturity on this food. In thus feeding the head is not turned over, as when feeding on plankton, and the mouth-brushes move slowly in accordance with the "gulps" taken by the trophi. The algal sheaths frequently pass from the rectum unbroken, and I have seen the larva as if transfixed by the filament, the contents of which are, however, broken up in the process; on other occasions, however, dissection has revealed the sheaths comminuted in the intestine, with their green contents collected in a compact mass, presumably undergoing digestion; but in this process the chlorophyll is not destroyed, for in such circumstances the faeces are green. A similar state of affairs has been found in the intestine of *Culex bitaeniorhynchus*.

A. maculatus has also been watched when placed with roots of *Mikania scandens*, along which it can be seen to browse, presumably nibbling off attached Diatoms and possibly the root hairs, but a magnification and working distance suitable for watching larvae thus engaged is too low to reveal the materials selected in such instances. *A. listoni* and *A. barbirostris* in the same circumstances do not thus browse along the roots, but continue feeding on plankton. *U. campestris* seems to share the habits of *A. maculatus*.

Larvae of *maculatus* from among *Mikania* roots have been dissected on more than one occasion. Among the earthy, brown contents of very minute particles could be found Naviculid Diatoms, the longer ones being bitten in half, many specimens of a *Cosmarium*, though this was not so numerically frequent as the Diatoms, and, on one occasion, many Ciliates of various species. The water of the spot, centrifuged, showed only a few of these forms, but the roots themselves were thick with the forms found in the gut.

A. maculatus, however, is at least as often found away from both *Spirogyra* and *Mikania* as amongst them, and larvae from such situations have also been dissected. Larvae from a tank with no water-plants of any kind of macroscopic size have been found to contain Diatoms and the organism I take to be a *Calothrix*, with the usual earthy matter. Larvae from a spring in a drain with hard vertical laterite sides, which had a few fallen leaves floating (the larvae were not associated with the latter, but were found along the sides), had the gut full of brown, sandy material, obviously from the sides of the drain, intermingled with which were Naviculid Diatoms, of which some of the largest had the tests empty, and many specimens of the *Bulbochaete* referred to previously. There were also, on one occasion, some insect hairs of doubtful provenance, showing that the larvae had fed on animals falling into the water. (In captivity *A. maculatus* is often cannibalistic.) The centrifuged plankton consisted of small Ciliates only, and the *Bulbochaete* was not found in it, though the sample was drawn from the edge near to where the larvae were feeding, and a further examination of the site showed that this organism was only common actually upon the earthen margins. The larvae must therefore have browsed along the sides to obtain it, and, from the quantity found in the gut, it is evidently a preferred food. At the same place, on one occasion, it increased in numbers and could then be found in the centrifuged plankton, but larvae were not then present, though there seemed to be no inhibitory water condition. As Table XI shows, the *Bulbochaete* has been found in the plankton on several occasions, both in association with larvae and without them.

Gut dissection, then, has not proved absolutely useless. It confirms Wesenbourg-Lund's statement that Diatoms are a principal source of food. Pressure of work in other directions has not so far permitted of my engaging in it systematically, but when this becomes possible I feel sure that it will yield information of value, more so than routine plankton examinations have done. It has already brought to light

one definite food organism, the *Bulbochaete*, which I had never encountered prior to finding it in the gut, and has shown that in addition to algae Ciliates are also eaten. Probably the latter are consumed much more largely than the evidence shows, being the main food when the larvae are engaged, as is generally the case, in filtering plankton organisms from apparently clear water; but these are too small to be visible under a magnification suitable for watching feeding, and being colourless and very delicate, are not likely to be found in recognisable form in the gut, save exceptionally. Now the tree-hole breeders, living in water which is often so thick with these organisms that they appear as whitish clouds in the liquid, must consume them in large numbers, at least such species as do any plankton feeding. On the few occasions when I have found a similar condition of affairs in bamboo-water it is noteworthy that, though pH and conductivity have been within the usual limits, the spot has been sterile as regards mosquitos. Water so foul as to produce this state of affairs is not inhabited by the natural-water breeders, or at least the Anophelines.

Now, presuming that algae and Ciliates living in water varying between pH 6.0 and 8.0 are ingested by larvae, what conditions do they meet with in the gut?

The structure of this organ is sufficiently described by Patton and Cragg (1913). In dissection it is comparatively easy to bring the peritrophic membrane and its contents away with the head, leaving the caeca and actual mid-gut to come away with the hind gut and Malpighian tubes by the posterior route. After thus dissecting, drops of indicator were added to the various parts and the colours judged against Clark's coloured plates as described by Jameson & Atkins (1921). The values thus obtained are only approximate, but it will be seen from Table XIII that the caeca are considerably less alkaline than the gut contents, of which the alkalinity is very high. This alkalinity must arise from the secreting cells of the mid gut, and not from the secretion of the caeca, though the latter probably plays a preliminary part in digestion. The alkalinity of the mid-gut increases towards the posterior end. Its pH value without the peritrophic membrane must be that of the blood. The hind gut and Malpighian tubes are much less alkaline, even at times acid, and are approximately equal in value.

TABLE XIII.
Hydrogen-ion Values of Larval Mosquito Guts.

Species.	No. examined.	Caeca.	Entire mid gut.	Mid gut only.	Peritrophic membrane & contents	Malpighian tubes.	Hind gut.	Remarks.
<i>Anopheles listoni</i> ...	9	7.0-7.6	8.4	7.0-7.2	8.6-8.8	6.8-7.2	6.6-7.0	Mid gut : 7.2 anterior, 7.8 posterior part.
<i>Anopheles maculatus</i>	14	7.2-8.0	—	7.0-8.0	8.8-9.4	6.8-8.0	7.0-8.0	
<i>Uranotaenia campestris</i>	10	7.2-7.8	—	6.2-7.8	9.0-9.6	7.0-7.6	6.4-7.4	Internal secretion of mid gut, 8.0.
<i>Megarhinus splendens</i>	1	—	7.2	—	8.8	7.2	6.8	Mid gut : 7.4 anterior, 7.8 posterior part.
<i>Culex bitaeniorhynchus</i>	10	7.4-8.4	—	7.2-8.2	8.8-9.4	7.2-7.8	7.4-7.6	
<i>Culex fusccephalus</i> ...	1	—	—	—	8.0	—	7.6	Diseased larva.
" " ...	8	7.8-8.0	—	7.6-8.0	8.8-9.0	7.2-8.0	7.2-8.0	
" " ...	1	—	—	—	8.0	7.8-8.0	—	Pupating larva.
" " ...	1	—	7.4	—	—	—	—	
<i>Stegomyia albopicta</i> ...	25	7.4-8.8	8.2-9.4	7.8-8.2	9.0-9.4	6.6-7.8	7.6-7.8	Pupa.

The values shown in Table XIII are very similar to those found by Jameson and Atkins for *Bombyx mori*, a phytophagous caterpillar with a single host-plant. They show very small differences between the various species. *Uranotaenia campestris* and *Stegomyia albopicta* are rather more alkaline in the gut than the other species examined, and *Anopheles listoni* is more acid than *A. maculatus*, the latter species being very much the same in every part as *Culex bitaeniorhynchus*, in which animal we must have the optimum values for the digestion of *Spirogyra*, its sole food. Disease or approaching pupation both seem to result in decreased alkalinity of the gut.

An extremely surprising finding was the quite similar values for *Megarhinus splendens*, an entirely predacious larva, which might therefore have been expected to show quite different results, but which explains how larvae that normally have quite diverse food-habits, such as those of *A. maculatus*, can safely become cannibals in captivity. Dissection of *M. splendens* revealed the not-uninteresting fact that it is not, as generally supposed, exclusively a Culiciphage, as a Hymenopterous head-capsule, probably that of a Chalcid, was found in the gut.

It will thus be seen that ingested algae, or organisms of any kind, find themselves in a medium far exceeding in alkalinity anything in which they have lived. This alone would serve to break them down, without the action of digestive ferments. Owing to the very minute quantities of fluid obtainable from larvae it will be a far from simple matter to attempt an investigation of the enzymes present, and time has not been found for this, but it is certain that in mosquito larvae, as in the silkworm, we have to do with a peculiar diastase acting in strongly alkaline solution. In digestion of algae the albumen of the pyrenoids and the surrounding starch will be metabolised, but the cellulose of the sheaths will, on the analogy of the silkworm, not be digested, unless (as has been suggested to me by Mr. Williamson, of the Malaria Bureau, Kuala Lumpur) cellulose-digesting bacteria are present. This is not a point which the resources of my present laboratory enable me to investigate.

In respect of the feeding values of various algae, so far as I can discover, very little has been published, and that solely in connection with marine forms. Johnson (1908, p. 189) quotes the following average analyses from Brandt (1898), from which it will be seen that the nutritive value of Diatoms is poor, owing to their high percentage of ash:—

		<i>Proteid.</i>	<i>Fat.</i>	<i>Carbohydrate.</i>	<i>Ash.</i>
Peridinians	...	13.0	1.3	80.5	5.2 per cent.
Diatoms	...	10.0	2.8	22.0	65.2 per cent.

On the metabolic requirements of mosquito larvae we are in the blankest ignorance.

IX. Causes of Larval Mortality.

As a natural corollary to any investigation of the tolerances of mosquito larvae, and in explanation of why they are absent from waters in which conditions are unsuited to them, it is necessary to investigate the causes of mortality in larvae which, directly or indirectly, must arise as an effect of such conditions.

Though Keilin (1921), in describing *Coelomomyces stegomyiae* discovered by Lamborn, gives a list of the known parasites of mosquitos, very little is really known on this subject, and the writer has so far not found it possible to do more than make a few rough observations.

MacGregor (1921) found that, in the laboratory, larvae in unsuitable conditions were attacked by a fungus of the genus *Saprolegnia*. According to this author, though it finds optimum conditions in an acid medium, the fungus acts, both in acidity and alkalinity, on larvae whose natural habitat is an alkaline medium when the latter becomes acid, and *vice versa*.

I have not come across either *Coccomomyces* or *Saprolegnia*, and Petch (1925) makes no mention of either in his recent list of the entomogenous fungi of Ceylon. Certain larvae that died in the laboratory, which I submitted to Mr. Petch as there was a fungus present, he found to be carrying a Hyphomycete with hyphae less than 1μ in diameter, but this was situated mainly on the hairs of the larvae, and was probably wholly external.

None the less, the effect of external organisms on the larvae may be almost as detrimental as true parasites. As Nicholls (1912) states, the movements of such larvae are sluggish, and their development slow. Wesenburg-Lund (1921) states that while young larvae are frequently supercompensated hydrostatically, older larvae are more often undercompensated, and if carrying a load of foreign organisms, especially fungi, to the hyphae of which silt particles may become attached, they may be unable to keep at the surface at all, and so be drowned. In any case they are rendered an easier prey to their enemies. It is noticeable that larvae in their last instar are more frequently attacked than are the younger stages. Amongst organisms which I have seen thus attached to larvae are Fungi, Vorticellid Ciliates (this is the most common form of attack), Volvocale Algae, and Rotifers of the genus *Philodina*.

Of course, if the larva survives until the next ecdysis, such purely external parasites are got rid of, supposing that the larva successfully accomplishes the moult. Also, should it find itself in better conditions, the attached organisms, especially *Vorticella*, will be killed off. This is very noticeable in the case of *Megarhinus splendens*, which, as originally noted by Green (1905), is usually thickly encrusted with these organisms in nature. If the larva is transferred to tap-water it will become clean in a day or two.

Quite another cause of mortality has been discovered and investigated by Roubaud (1923), who attributes to it the fact that where larvae are numerous and easy to find adults are often scarce, and *vice versa*. This is the auto-intoxication of larvae by the ingestion of the excretory products of themselves and their fellows. Whether Roubaud is correct in allowing this so great an importance in nature I have not yet attempted to study, and in any case in the wet Tropics larvae seem to be more evenly and widely distributed than they are in colder climates; but there is no doubt that it is a major cause of mortality in the confined conditions of the laboratory. Mortality is much higher in a crowded breeding-bowl than in one with only a few larvae.

The causes of death, then, are numerous and varied. There are endo- and ectoparasitic fungi and Protozoa, and organisms which attach themselves to the larva and cripple its movements, thus rendering it a victim to definite predators and purely metabolic disorders. The whole subject of mosquito diseases has hardly been touched and must hold much of extraordinary interest. A few observations that have been made by the writer are, however, perhaps worth setting forth.

Sulphur Bacteria.—Frequently one finds at the bottom of shallow drains, pools in streams, and among rice, perhaps most often in uncultivated swamps in rice-fields, masses of a brownish-red or greyish (the latter less frequent) flocculent material, often forming a film on all the water-plants. At times trickling seepage springs in laterite subsoil at the sides of ravines may show pendulous masses of this material, giving an appearance as if there had been a general use of the edge of the bank as a latrine. The material, on examination, is found to consist of a flocculent mass of ferric hydroxide, intermingled with hyphae, and wherever this growth is seen it is invariably found that mosquito life is absent, though larvae may occur not far off, in places clear of the growth.

These pools with a bottom deposit of ferric hydroxide have been described by Fritsch (1907). He showed that ferric chloride was present in solution in small

amounts, but in nearly every respect his description of their flora differs entirely from my own experiences. He states: "In a dozen typical cases examined from different parts of the Island, neither *Spirogyra* nor *Oedogonium* were ever found to be absent from the pools, although the one or the other (very rarely both) were occasionally only present in small quantity." As mentioned on page 232, I have only twice found *Spirogyra* overlying this growth, and once only in considerable quantity. Fritsch goes on to describe in some detail the plants associated with this formation, mainly Desmids, which should, though I have not met with most of them, form suitable larval foods. Dealing with the relationship of this flora to the deposit, he favours the idea that the latter is due to the activity of the algae present, though it is not, he admits, impossible that iron bacteria may have a hand in the process. But he does not think that these deposits can be solely due to their agency, for in many cases he found that there were very few bacteria evident, and that they seemed to occur more commonly in the later stages. "The gradual increase of the deposit may produce less favourable conditions (? shading) for certain algal forms, which thereupon disappear. In the diverse pools studied, many cases suggestive of the above theory were met with. Thus, in some of the pools, the granular matter merely formed a flocculent covering to the contained vegetation, and there was little or none on the bottom; in others there was a quantity of the reddish-brown deposit on the bottom, as well as enveloping the plant-growth present; whilst, in still others, there was only a dense granular layer on the bottom, and practically no vegetation rising up into the water above it. In the pools last mentioned the vegetation was generally scanty and least satisfactory, from the point of view of uniformity with the others. Such pools generally also contained a quantity of *Leptothrix*; and it seems as though this genus finds favourable conditions as the deposit accumulated; possibly it is the direct cause of the disappearance of the main mass of algal growth. In any case, the ultimate result of the accumulation of the red deposit is the elimination of a considerable mass of the vegetation. What this process leads to finally, I am unable to say, but there are some indications of the initial state of affairs to be found in pools and ditches having no trace of the characteristic deposit, but containing a flora very similar to that above described."

I am very familiar with both the second and third stages of the growth as described by Prof. Fritsch, but I have not observed one stage passing into the other. The plant growth in the second stage, in cases encountered by me, has been mainly *Colocasia* and the trailing roots of grasses and terrestrial creepers, *Mikania* and *Desmodium*, and I have yet to see these killed out, or rising clean from growth which has sunk. Much closer attention to this growth than I have yet given it is required, especially in regard to conditions preceding and at the time of its first appearance. Possibly it is only when the *Leptothrix* has become well established, with disappearance of the algae, that conditions inhibitory to mosquito breeding supervene.

Again, if such a deposit be watched, it will be found, after its disappearance, or at times commingled with it, that there arises an iridescent scum, as if the water carried an oil film. This is equally indicative of an entire absence of mosquito life. Microscopically this film is found to consist of irregular, dirty-yellow scales, which produce the field appearance by interference effects, and which consist, probably, of free sulphur. It is extremely seldom, however, that any odour of H_2S is noticeable.

The conditions of life of the sulphur bacteria have been investigated by Ellis (1924), who states: "The sulphur bacteria are found in shallow waters, both marine and fresh, and play an active part in the decomposition of animal and vegetable matter. They require for their full development an abundant supply of oxygen and of sulphuretted hydrogen. They do not thrive unless the water is periodically renewed, or else is so shallow that oxygen is obtainable to a fairly large extent from the atmosphere. When the oxygen is used up their development rapidly comes to an end. . . . They derive their supply of sulphuretted hydrogen from the decomposition of the protein molecule of vegetable and animal matter. Usually a growth of

sulphur bacteria is visible to the naked eye as a greyish or reddish mantle covering the surface of a mass of decomposing organic matter. If, for some reason or other, the supply of oxygen is not plentiful at the bottom of the pool, the mass of growth leaves the surface of the decomposing matter and moves nearer the surface of the water. . . . The same general conditions apply to the incidence of the growth of the sulphur bacteria in fresh water. They appear either in quiescent pools or in streams that run their course sluggishly across marshes. Sulphuretted hydrogen and oxygen must be supplied, and if the latter be used up in any particular pool, the disappearance of the sulphur bacteria quickly follows. As a class the sulphur bacteria are sensitive to the amount of organic matter in solution, for when this organic matter reaches a point of concentration which permits of the free development of the saprophytic bacteria the sulphur bacteria rapidly disappear. Their growth and development are dependent upon a delicate adjustment of a set of conditions which are easily upset. The delicacy of this adjustment is such that up to the present all attempts to produce pure cultures have failed."

Now there are certain discrepancies in the growth as described by Ellis and the conditions as recorded by myself. Ellis describes it as mainly occurring on decomposing organic matter, whereas I have found it either free, subaerially or on the bottom of the water mass, or coating the living plants themselves, as described by Fritsch. It may well be that different organisms are involved. Samples from many localities have been supplied to Dr. Ellis, and his report must be awaited. But whatever this growth may be, it is, as shown above, indubitable that related to it is some condition of the water which is completely inhibitory to mosquito larvae. This is not a pH effect. Records on the presence of the growth are given in Table XIV, from which it is seen that the optimum for its appearance is pH 6·8,* and this is a value at which practically every mosquito can flourish. Conductivity measurements run from extremely pure water at 99 up to a brackish road-side drain at 27,683, which may have contained nearly 75 per cent. sea-water, unless the conductivity was due, at least in part, to other solutes, which, from the situation, was impossible. So far, no oxygen measurements have been made in the growth itself. A single measurement in the residual iridescent scum gave 3·20 mg. %_∞, with 0·5 p.p.m. of ammonia.

TABLE XIV.

Hydrogen-ion Concentration and Sulphur Bacteria Distribution.

pH	5·8	6·0	6·2	6·4	6·6	6·8	7·0	7·2
Times found	0	1	3	4	4	11	4	0

In waters where this growth flourishes, GERRINAE may be quite plentiful, but these bugs live above and not below the surface-film; like mosquito larvae, however, most other forms of aquatic animal life are absent from the body of such waters. Once only, I have found Cladocera present. One one occasion I have found a mass of *Spirogyra* overlying a bottom growth of sulphur bacteria in a stream, and mosquito larvae were present among the algal filamentation; on another, a few filaments were found among the growth, but there were no mosquito larvae associated. As *Spirogyra* is known to be extremely sensitive to even minute traces of toxic substances, its presence under such conditions is not easily explicable. It can only be suggested that what is toxic in the growth for mosquito larvae is, on the contrary, utilised by the alga in its metabolism, leaving the water around the filaments suitable for larvae. The pH on the occasion described was 6·2, which is not the optimum for the bacterial growth.

* At one site, in two observations at intervals of a month, the growth was very massive at pH 6·8, and had completely disappeared at pH 7·2 the month following.

Now hydrogen sulphide is known to be extremely toxic to mosquito larvae, as shown by Williamson (1924), and their absence from water with this growth would be at once explained if the presence of this gas in solution could be demonstrated. But, as stated above, it is extremely seldom that any odour of it can be detected. Ellis states that the H_2S evolved by the saprophytic bacteria is utilised by the sulphur bacteria, but that if the former develop freely, the latter fail. This would indicate that H_2S must not be produced in excess of the amount required for the growth of the sulphur bacteria, which would mean that none would remain free in the water to poison mosquito larvae. This agrees with the absence of any odour of the gas from such situations, but leaves the question of what kills the larvae unanswered. The whole question wants investigation *de novo* from the latter standpoint. Possibly the bacteria are iron bacteria, not sulphur.

Calcium Carbonate Precipitation.—Another cause of death was encountered on one occasion. A collection of larvae including some *A. listoni* was made in a ravine stream, with pH 7.1. Apparatus for conductivity measurements was not at this period available, but subsequent measurements of the water of this site show it to be usually around 700. Owing probably to the respiration of some tadpoles, which were brought in in the same bottle for another purpose, the water, when transferred to breeding bowls in the laboratory, stood at pH 7.0. The various species of larvae were separated. The occurrence to be described affected those of *A. listoni* only. The water in the bowl containing them was faintly indicated with brom-thymol-blue, so that the pH changes could be watched continuously.

As usual, the pH in the bowl commenced to rise. In four hours it reached 7.4, but the water could be blown back to its original value, by breathing through it down a glass tube, in a few minutes, showing that the rise in pH was entirely due to loss of CO_2 , and not to ammonia absorption. This point being settled, the bowl was left undisturbed to watch the rise in pH, and its effect on the larvae.

Mortality commenced in a few days, when pH had risen to 8.0, and continued whilst it rose to the maximum of 8.6. What were thought to be globular spores of a fungus were found on the larvae, mainly situated between the lateral hair-tufts. The larvae then experienced difficulty in movement and in keeping at the surface, and gradually sank and were drowned. The dead larvae were preserved and sent to Mr. Petch, whose findings are best told in his own words: "When I first examined a specimen I thought I had an easy thing on, as it bore numerous large spherical bodies, with a dark centre and a broad translucent edge, just like large thick-walled spores. But on running in lactic acid to make things clearer, they all fizzed and disappeared. They were evidently sphaerocrystals of calcium carbonate."

The effect therefore was of the same nature as that found by MacLendon in Marquesas Lagoon, as quoted by Atkins (1922), only in my case the CO_2 was not being removed by plants but mainly by increased temperatures. The reason why the calcium carbonate was deposited on the larvae, which are surface feeders, would be explicable by the fact that CO_2 -loss would take place from the surface layers, where the larvae would afford the nearest point of attachment for the carbonate crystals, though it is probable that more of this was precipitated unnoticed than was actually found on the larvae. On them its effect was to destroy their hydrostatic balance and drown them. A mass of plant life in a very hard water such as is commonly encountered in Ceylon streams would also remove CO_2 in sufficient quantities to precipitate $CaCO_3$ on larvae; but not only are aquatic plants in such streams of very sparse occurrence, but the larvae which inhabit them, being almost entirely surface dwellers, would not in such a case be affected by the carbonate precipitated. The destruction of larvae by sphaerocrystals of $CaCO_3$ has never again been observed. Probably it is a laboratory phenomenon only, but it is none the less interesting and worthy of record.

As regards Roubaud's hypothesis of the intoxication of overcrowded larvae by the urates excreted by themselves and their fellows, which, he states, remain in the water in the form of insoluble particles, the hypertrophy of the Malpighian tubes resulting therefrom is noticeable, even in undissected larvae. As Roubaud (1923) states: "Les tubes des larves intoxiquées se reconnaissent de plus immédiatement à leur coloration blanchâtre, et à leur aspect opaque dû à l'accumulation des granules d'excrétion. On peut déceler par transparence les cordons malpighiens des larves en souffrance."

Roubaud dealt only with the condition of the Malpighian tubes in larval *Anopheles*. In a species of *Culex* thus intoxicated I have observed the process go further than the mere hypertrophy of the tubes as figured by Roubaud, for in my case the apical cells had disintegrated, leaving only the chitinous sheath of the tube intact. The cells lower down the tube were hypertrophied. These larvae, though living, were obviously very ill. The heart was beating, though the movements of the larvae were very sluggish, 135 per minute. The only Culicid on which any observations of the normal heart-rate seem to have been made is *Corethra plumicornis*, investigated by Dogiel, as quoted by Packard (1909). The Russian observer found a normal of 12-18 beats per minute whilst at rest, rising to 22 during activity. Application of CO₂ caused a rise to 25 per minute. Until an investigation of the normal rate in various Culicine larvae has been made it is impossible to indicate what degree of acceleration the rate of 135 found in my diseased larvae represents, but it is certainly very high,* even allowing for a tropical temperature.

Some of these intoxicated *Culex* larvae pupated. The pupae were abnormal, the head capsule half free from the thorax, the breathing trumpets on which were malformed, and the abdomen not properly recurved. The pupa was under-compensated, which is abnormal, and at rest almost resembled that of a *Chaoborus*. There were no emergences.

I have more than once seen larvae in unhealthy circumstances die with a hernia on the neck, and with prolapse of the peritrophic membrane. Both symptoms were seen in some of the *Culex* larvae just referred to, and I have seen the same fatalities happen to *A. aikenii* and to *A. listoni*. Everyone will have noticed a very common death-appearance in larvae, with the neck enormously elongated.

On the other hand, larvae of the artificial water groups, at least those which normally live crowded in small and unrenowned volumes of water, must be largely immune from this form of intoxication. I have seen *Armigeres obturbans* live for 63 days in what was originally about half a pint of liquid, but which by evaporation had become reduced to about one-eighth its original volume. During this time 142 adults were produced, all from the egg stage. The proportion of excretory products in this liquid must, towards the end of the experiment, have been very great. I could not, however, obtain the murexide reaction.

X. The Detailed Study of some typical Water-bodies.

For a year the seasonal movements of the various factors studied during this investigation have been measured in several bodies of water situated at a convenient distance from the laboratory, in an attempt to correlate these with the various mosquitos present in the water on each occasion. Examinations have been made at approximately weekly intervals. Out of these four have been selected for description here, as illustrating the course of events in water of various types.

* Larvae, probably those of *C. fatigans*, apparently healthy, have been seen to have a regular heart-beat of 62 per minute. *Armigeres obturbans*, a very active larva, in the same water, was breathing 36 per minute, the beats being irregular.

TANK "A."—A miniature artificial irrigation tank, approximately 40ft. by 20 ft., formed by a stone retaining-wall across a ravine. The source of water is one or more springs which arise in the bed of the tank, or trickle down its upper-end bank. Stream water does not enter. The depth nowhere exceeds more than four feet, but can be artificially regulated by sluices, which are opened in wet weather, when a certain amount of surface drainage also enters. The tank is surrounded by trees, mainly *Caryota urens*, *Areca catechu* and *Theobroma cacao*, which throw considerable shade over the water during most of the day. The phanerogamic flora of the tank consists mainly of *Limnophila sessiliflora* and *Aponogeton monostachyon*, with a little *Monochoria hastifolia*, and these, except in a portion where the bottom is rock, are in more or less complete occupation of the whole volume, and usually have aerial portions as well. There is a varying amount of *Nitella mucronata*, which, however, does not usually approach the surface. The algal flora and its variations are discussed along with the examination results.

DRAIN "CA."—A spring which arises in an estate contour drain at a hill-foot. There is a certain amount of shade from rubber (*Hevea brasiliensis*), and a native-owned "garden," mostly of cacao and economic palms, near by. The sides of the drain are vertical, in laterite subsoil. There is no water vegetation other than algal, and the pool formed by the spring is liable to flushing-out by surface water coming down the drain in rainy weather.

IRRIGATION-CHANNEL "G."—An irrigation-channel such as is commonly found in the Ceylon foot-hills. The source of the water is partly a small stream, partly the overflow from tank "A," and partly that of the spring in drain "CA." The owners of the channel are, in part at least, more agriculturally enlightened than the average of Ceylon rice-field owners, and the course of the channel is kept cleaner than usual. This has an adverse effect on the amount of mosquito breeding. There are no water phanerogams, but in places the channel is grass-edged, and the roots of creepers, mainly *Mikania scandens*, trail in the water here and there, but for the most part the margins are either bare laterite or silt-banks. There is a good deal of overhanging shade from village gardens.

RICE-FIELD "F." Irrigated from "G" by the usual Ceylon method of small mud dams at intervals, raising the water to the levels of pipes made of bamboos with the septa knocked out, buried in the bank between the channel and the field. These dams are made or removed by a few strokes of the tool as required. I think springs also arise in the fields themselves from the hill-foot, and there is some seepage from the channel. The field is never completely dry, and the soil is a deep, impalpable mud. Throughout the period of examination there has been no portion left uncultivated. From the point of this investigation, this is to be regretted, as such uncultivated swampy areas* carry a much larger mosquito fauna than do cultivated rice-fields. The mud divisions (bunds), between the various blocks in the fields carry a flora of various grasses, *Isachne kunthiana* and *Eragrostis interrupta* predominating, which are not removed, save at the commencement of each season's cultivation, and afford a little shade close against the edges of the various plots, and it is mainly in such situations that larvae are found.

Now, in examining water for mosquitos it would be very desirable if it were possible to measure "density" as is now commonly done in *Glossina* investigations (Fiske 1920), but so far a practicable method has not been evolved. In *Glossina* work the observer has only to stand still and the insects will come to him from the terrain surrounding the spot under examination, but in investigating a piece of water hunting likely spots along its length has to be done. Now it is well known to all mosquito workers that larval distribution is very patchy; they may be numerous in a small

* The Phanerogamic vegetation in such spots usually consists of *Kyllinga monocephala*, *Vandellia pedunculata*, *Cyperus pilosus*, *Fimbristylis dichotoma*, and *Isachne kunthiana*.

"bay" in the bank, or behind a tree-root, and there may be none for many yards on each side of this. The difficulties in rice-field work are greatly increased by the impossibility of moving away from the bunds, as the earth in the fields is too soft to support a man, and in any case it is impossible on account of damage to the growing paddy. Throughout this investigation the same spots in the various bodies of water were examined week by week, after the original discovery of favoured locations in each, which were known to me previous to the commencement of the present research. I attempted to measure "density" by catching for a given number of minutes, but abandoned it as useless. Striking with a net and transfer of the captured fly to a killing-bottle is a set of movements which cover a far less variable length of time than pipetting dodging larvae from a ladle to a tube, especially when there may be any number from 1 to 20 larvae captured at one "dip." All that can be said is that dipping was continued until a sample representative of that particular spot was obtained. Longer time was spent over a "nil" record than over one yielding larvae. The numbers given for larvae captured are, however, at most only relatively valuable.

In the figures of results the movements of the various quantities measured are graphed in the usual way. The rainfall is graphed at two-day intervals, irrespective of examination dates, periods of wet weather being thus better brought out—a fall of 2 ins. in one day being a very different matter in regard to mosquitos from the same amount spread over a week. The long rectangles show the periods within which larvae of the various species were found in the water, whilst the figures within them indicate the number of larvae captured on each occasion. A blank examination is indicated by a vertical line across the part of the figure devoted to larval findings. An "F" placed against a "nil" line indicates that this result is probably due to flushing by heavy rain and not by any of the quantities under measurement having varied adversely. In regard to bodies of moving water, a continuous line parallel to the abscissa indicates flow, an interrupted line stagnation. Ammonia was only measured between July and December, being thereafter abandoned for the reasons given in Section VI.

Turning now to the findings for the various localities.

TANK "A" (fig. 4).—The pH fell slowly from 6.8 to 6.4 from March to May. Thereafter, up to the end of October, it remained at the lower value, with brief fluctuations upwards coinciding with periods of heavy rain, until the onset of the north-east monsoon raised it to 6.5, whilst after the heavy January rains it rose to 6.6. The conductivity showed maxima during periods of low rainfall on 25.viii., 20.x., and 6.i. respectively, but subsequent heavier falls did not reduce it immediately. Oxygen has been well below saturation limits throughout. It reached its maximum coincident with the burst of the north-east monsoon early in November, but that this was not a direct rainfall effect due to the beating-up of the surface by the falling drops is shown by the absence of a similar rise correlated with the heavier January fall. To some extent oxygen-content has varied inversely with the conductivity, but the correlation is too bad to have any meaning.

The "residual" pH, as a measure of CO_2 -pressure, as explained on page 193, has fluctuated far less than the natural pH, and more or less independently of it.

Turning now to the algae, *Spirogyra* flourished up to 19.v., and during this period there were a few other species present as well as *Culex bitaeniorhynchus*, dependent upon it. The alga, and with it all mosquito life, disappeared on that date with a fall in pH to 6.4. Thereafter it was replaced by *Oedogonium*, which in turn disappeared at the end of August, leaving *Hapalosiphon laminosus*, which had been present from April, as the only macroscopic alga (excluding the deep-growing *Nitella*) up to the middle of February, when the tank and all its vegetation was cleaned out by the owners. From May to January the tank was absolutely devoid of mosquito life, save once when a single *A. maculatus* was found in November correlated with

Fig. IV. TANK "A".

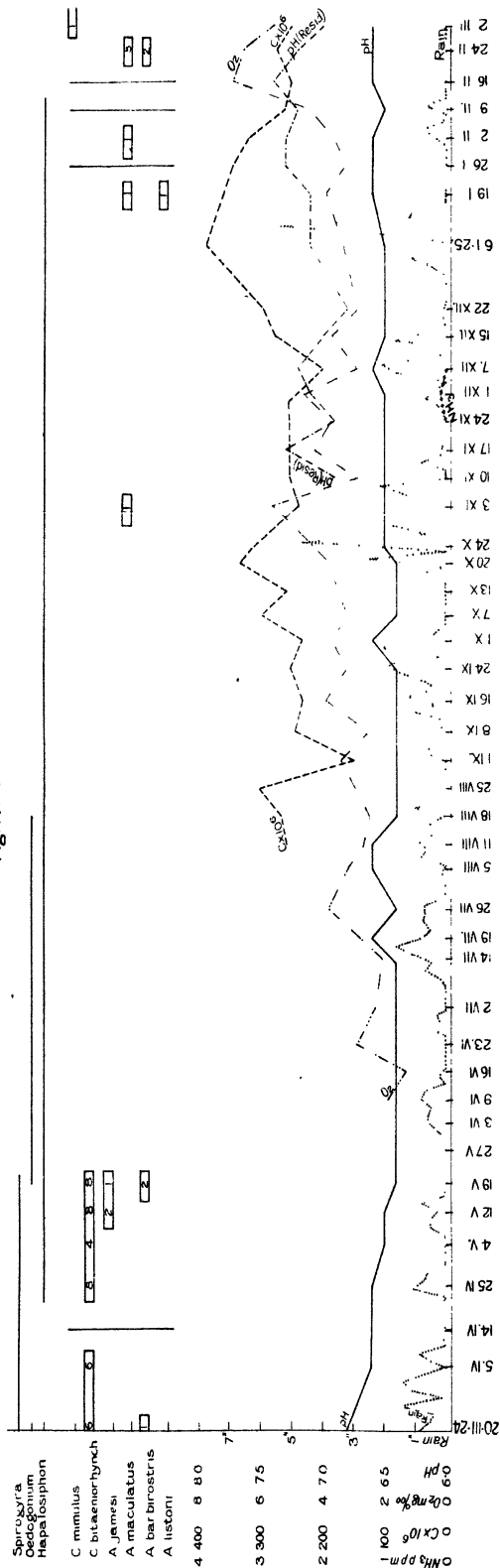
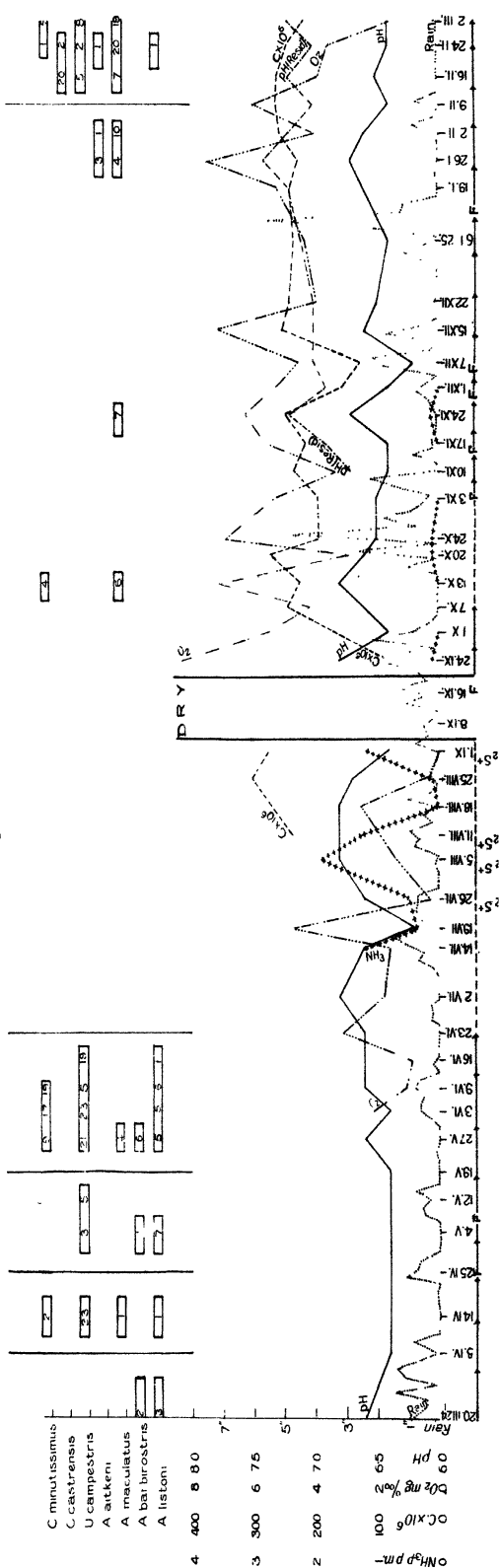


Fig. V. DRAIN "CA".



Cladophora on a fallen cacao pod, as related in Section VIII, whilst the two species found on 19.i. is another instance of the same association. Whether the single *maculatus* of two weeks later was associated with the outburst of *Closterium* which then occurred I cannot say. On that examination the entire surface of the tank was searched for nearly two hours in an attempt to obtain specimens of a *Hydra* that is known to occur here. The single larva was found in the tow-nettings and was almost certainly the only one in the whole tank. Immediately the vegetation was removed in February there was a big rise in oxygen, and larvae became at least less uncommon. This tends to indicate that the water of this tank contains organic substances, possibly elaborated by some of the vegetation, which are inimical to larvae.

Now, in years prior to the present investigation, the mosquitos of this tank have been examined periodically and have proved to be much more numerous than they were in 1924-25. Only one factor has visibly changed. In the past there was a considerable growth of *Pistia stratiotes* in the tank, but now there is none, it having all been removed by the owners at some previous cleaning. In the past, with *Pistia* present, the other plants, phanerogamic and algal, being unchanged, there was found over the first four months of the year a numerous fauna, in which *A. listoni* and *A. barbirostris* were the common, and *A. maculatus* a rare Anopheline, with *Culex mimulus* and *C. bitaeniorhynchus* both common; *C. minutissimus* and *L. fuscana* appeared occasionally. This fauna also disappeared at the end of May, and some subsequent examinations during the next two months showed sterility. This was not correlated with the removal of the *Pistia*. It would appear then that mosquitos only flourish in this tank during the spring months, between the N.E. and S.W. monsoons, and only then in the presence of *Pistia*. Without it, if *Spirogyra* is present, it will support a limited mosquito fauna, which disappears with it at about the end of this period of the year.

Here, then, is a problem which the present series of observations quite fails to solve. Evidently a big change takes place in the water-content about the end of May. This probably declares itself by a small drop in pH, but it is evidently of far greater moment than this, and its nature yet remains to be discovered.

DRAIN "CA" (fig. 5).—The controlling factor here is obviously whether the water is flowing out from the spring down the drain or not. Flow occurred from the start of examination in March up to the end of June. Thereafter the volume of the pool became less and less, until it dried up completely during part of September, the out-flow not being again permanently established until the onset of the N.E. monsoon in November. Throughout this monsoon flushings were frequent, though "breaks" in it allowed of sporadic breeding, on 13.x. and 24.xi., but not at the end of December, and with the advent of the inter-monsoon dry period mosquitos again commenced to breed in numbers.

The pH was fairly constant from March to June, but fluctuated widely during the ensuing period of stagnation, during which, in addition, the ammonia-content was high, and in its presence, on 14.vii., though *Spirogyra* made a transitory appearance, no larvae were found. Oxygen, as would be expected, was low during stagnation and higher during flow, but is not inversely related to ammonia, as might be expected; and when H_2S reveals itself by its odour, it is invariably low. Rainfall does not seem to be related to conductivity, but the latter has an inverse relationship to oxygen. The February-March carpet of fallen rubber leaves (the trees "winter" at this time) is favourable to the presence of numerous larvae of several species, in spite of a progressive absorption of oxygen, probably due to bacterial activity. In general, there are indications that, except under the leaf carpet, *A. maculatus* is only present at a pH of 6.6; but the other species breeding here are not so particular, though they mostly possess narrower tolerances. The residual pH indicates high CO_2 -pressure throughout, but here there is a direct relationship between this and the natural value.

In this place, again, we see larval life at its maximum during the inter-monsoon spring period.

IRRIGATION-CHANNEL "G" (fig. 6).—Here pH only ranges a few points on each side of neutrality throughout. It never approaches values at which any limiting effect on the various species inhabiting the channel can exist. Residual pH shows high CO₂-pressure, varying as a rule directly with the natural value. Conductivity is in inverse relationship to rainfall, whilst, almost as clearly, oxygen again varies inversely as conductivity. Ammonia was only found in considerable amount once, on 1.ix., and is related to a sharp rise in conductivity and drop in oxygen, but, strangely, not with the absence of *A. listoni* and *A. maculatus*.

The very high conductivity and low oxygen content in October probably mean faecal pollution, but saline ammonia was not found; possibly the amino-compounds were washed down before nitrifying bacteria could form it. Mosquitos are most numerous in May to July, a period when there was more damming of the flow for irrigation purposes than at any other. The rotting of grass weeded off the banks in July produced *C. tritaeniorhynchus* and *C. fuscocephalus* with the predatory *L. fuscana*, which were otherwise absent, but to state this is tantamount to saying that this rotting grass introduced a still unknown and unmeasured water factor. *C. bitaeniorhynchus* followed the only appearance of *Spirogyra* in June and July. Of the Anophelines, the channel is evidently primarily suitable for *A. maculatus*, as would be expected; *A. barbirostris* is dependent on the stopping of current by earth dams, but *A. listoni* followed *A. maculatus* until September.

RICE-FIELD "F" (fig. 7).—Here we see fluctuations of all factors far exceeding anything encountered in the other waters examined, as would be expected from the variations in the water-level artificially induced for cultivation purposes. As the effects of cultivation are the inducing cause, it will be simpler to study the changes caused by the different phases of this together.

On 14.iv. the soil was as nearly dried off as possible, with the previous crop being reaped. A few young larvae were found in puddles, the very high conductivity of which showed that their water was more relict irrigation-water than the results of fairly heavy rain a fortnight earlier. Water was admitted after reaping, and first ploughing took place, examination being made as soon as this was over, when there was about 3 inches of water over the bare mud. Very little fall in conductivity was occasioned by this flooding, but a considerable rise in pH. Larvae of standing-water breeders were found sparsely in small collections of floating debris, straw, etc., in angles of the field. Further water was then admitted and the mud levelled. At the same time the grass on the bunds was cut and thrown into the water. A small fall in conductivity again occurred with the extra water, with a return of pH to the original figure. *A. listoni* and *A. barbirostris* appeared sparsely, with a *Culex*, probably *fuscocephalus*, as in the week previous. Nothing further was done for a week, but though conditions remained unchanged, conductivity again fell, whilst pH rose to the highest figure recorded throughout. *A. listoni* disappeared, but *barbirostris* and the *Culex* persisted. In the following week the field was manured, a mixture of cowdung and *Erythrina lithosperma* leaves being worked into the mud. When the next examination was made the water was still turbid. With this addition of soluble material conductivity commenced to rise, pH falling sharply. The field was then dried off, water only remaining in the shallow drains made during final levelling, and seed was broadcasted. At the time of examination it was just sprouting. Conditions at once favoured *A. vagus*. Water was still kept short, but *Spirogyra* appeared, larvae being only found amongst it, the species being still *A. vagus* and not *C. bitaeniorhynchus*. Oxygen measurements, begun at this time, showed a fair proportion present; pH fell sharply; conductivity rose further.

On 9.vi. the paddy, now 12 inches high, was flooded to a depth of several inches. Though conductivity fell, and with it pH down to neutrality, oxygen remained

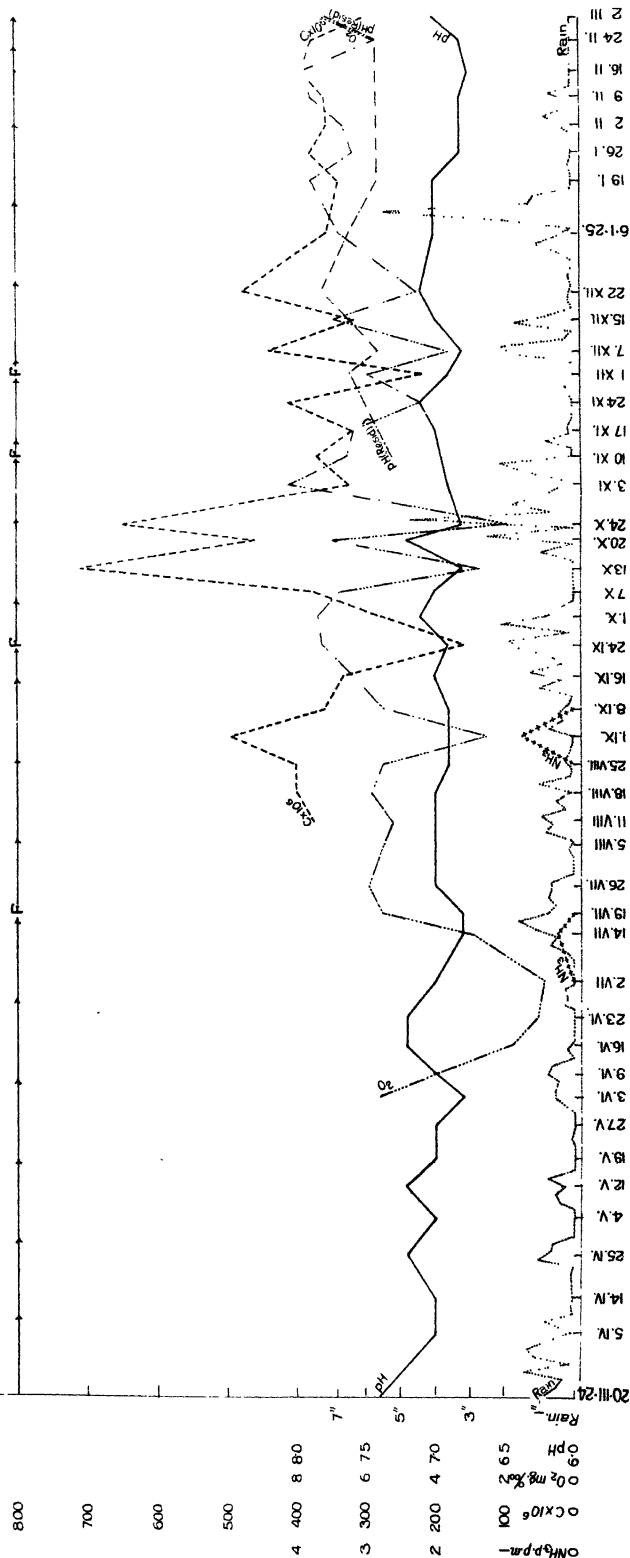
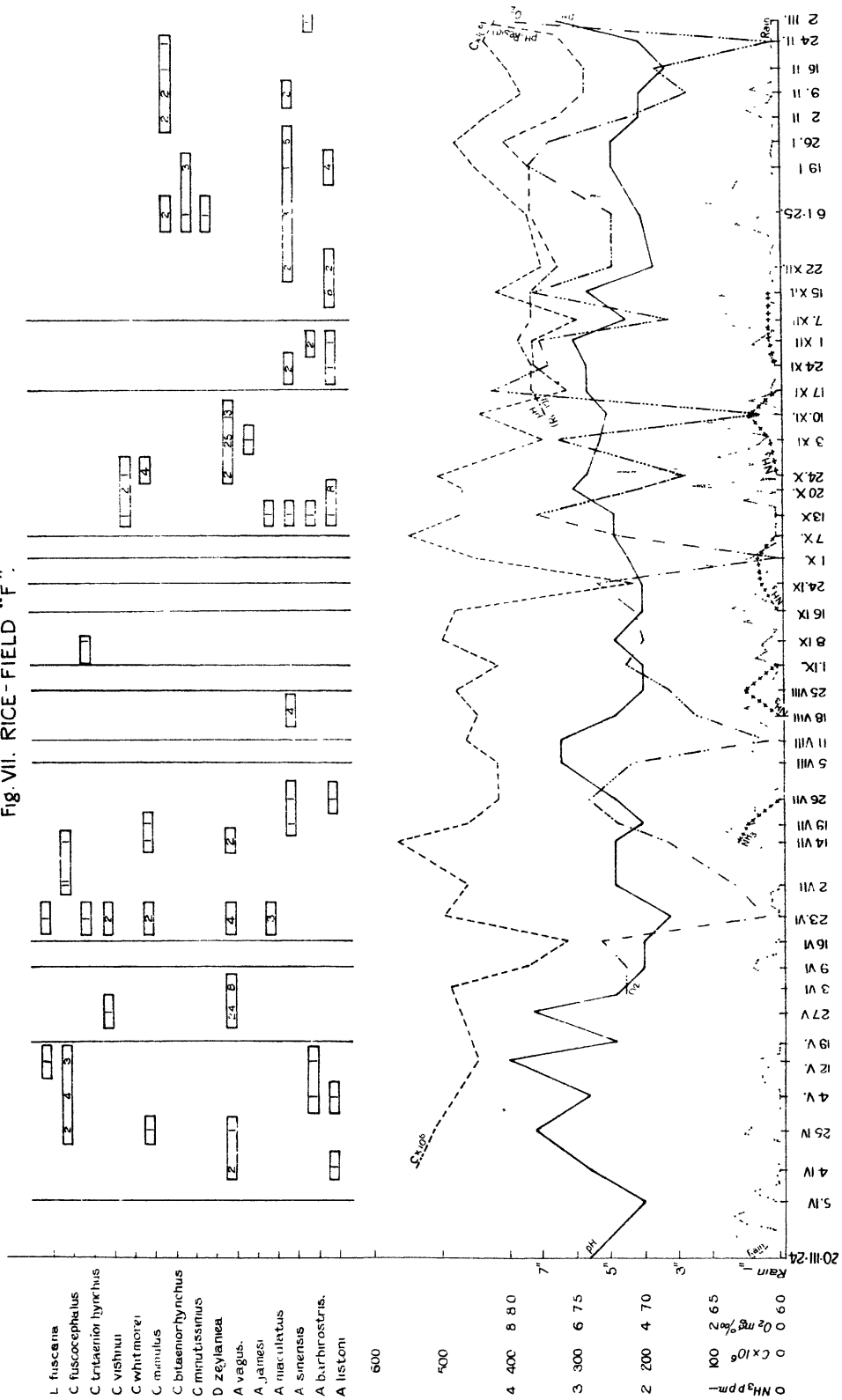
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Fig. VII. RICE-FIELD "F".



unchanged. Larvae disappeared, and were absent the following week, with the same conditions, though the flushing of the irrigation channel water through the field had further lowered conductivity but increased dissolved oxygen.

The following week (23.vi.), with the paddy now forming a thick stand, and consequently less current through the field, conductivity had again risen to a high value, but oxygen had nearly disappeared, and the water was acid. These changes were probably correlated with the manuring of a month previously. Numerous standing-water species had appeared, with a few diseased *A. maculatus*. This species was present in the irrigation-channel at the time, and these specimens had doubtless been carried through the pipes into an unfavourable environment.

For the next month (to 19.vii.), irrigation water was alternately applied and run off. The examination of 2.vii. was made during a flooding, that of 14.vii. during a drying period. The pH remained unaffected, but conductivity naturally rose with drying, as also did oxygen, though less comprehensibly, especially as the commencement of ammonia measurements on 14.vii. shows that some quantity of this was present. Throughout this period the standing-water breeders were in evidence, with a few diseased *A. sinensis* amongst them. At the topmost limit of oxygen attained, *A. listoni* put in an appearance.

On 5.viii. the paddy was in ear, and the field dried off. Sulphur bacteria had appeared, with consequent sterility. The pH was measured well away from this in the hope of finding larvae. It had risen very considerably, without related changes in oxygen and conductivity; ammonia was absent. The following week, dried off for ripening, the only change was a second almost complete disappearance of oxygen from the remaining water. On 18.viii., water being in a film only, sulphur bacteria had disappeared, leaving sulphur scales only, pH had fallen and oxygen was beginning to rise. A small but healthy family of *A. sinensis* was found. The following week, just before harvest, pH had fallen to neutral, but though there was again ammonia present, oxygen had returned to a higher figure.

Immediately after harvest, on 1.ix., the field was flooded for the "maha" (major) crop of the year. This is originally grown in seed-beds and then transplanted, not broadcasted. Flooding, though it increased oxygen content, only slightly reduced conductivity, and produced no larvae. Ploughing in the week prior to 8.ix. increased the amount of solutes present, and raised pH slightly, but barely affected oxygen. The single mosquito found was of a standing-water species and was in the pupal stage. It had bred here, probably among floating stubble, and had not come in from the channel.

On 16.ix., though the bunds had been cleaned and grass thrown into the water on the fields, flooded for nursery purposes to 2 inches or more, no larvae were present, though no factor had moved. On 24.ix., in a film of water in a nursery, no larvae were found. Heavy rain had evidently greatly diluted the water remaining in the field. Ammonia had appeared again, but oxygen had risen. For the next two weeks, with only a water-film on the nursery beds, a return of conductivity to more than the former high value was accompanied by a slightly rising pH, but now ammonia of about the same amount as just before was correlated with complete removal of oxygen and mosquito sterility.

On 13.x. the nursery was again flooded prior to transplanting. Ammonia had disappeared, oxygen rose, conductivity and pH fell slightly. There appeared *A. maculatus* and *A. listoni*, the latter of which was breeding in the channel at this time, with *A. sinensis*, *A. barbirostris* and a *Culex*. Transplanting a week later raised pH owing to mud disturbance, and decreased oxygen, causing the *A. listoni*, which had further increased, to become diseased; the *Culex* persisted. At the end of transplanting, on 24.x., with about 1 inch depth of water, oxygen had further decreased, and the *Culex* had been joined by *A. vagus*; there were signs of free sulphur.

In the first week of November, with only a water-film, *A. vagus* was numerous, oxygen having meanwhile risen and conductivity fallen sharply, probably owing to the initial heavy rains of the N.E. monsoon.

On 10.xi., with a stagnant film only, oxygen was again reduced to almost vanishing point, with a rise in ammonia and conductivity. All this time pH was only fluctuating slightly. The measurement of residual pH, now begun, showed a certain amount of CO₂ only. *A. vagus* persisted in some numbers.

The week following, with water about 1 inch deep, oxygen rose to the highest value recorded in the field during the year. There was a sharp drop in conductivity, but very little alteration in pH, whilst the CO₂-pressure remained unchanged. Larvae were absent, but the next two examinations revealed the appearance of a few *A. listoni*, probably in some way related to the increased purity of the water as indicated by its high oxygen content, which was well maintained, ammonia meanwhile having become reduced to a trace only.

On 7.xii. there was another sharp drop in oxygen, with pH and conductivity also reduced, but not to the same extent, with a rise in CO₂-pressure. Larvae were again absent, but another big rise in oxygen again introduced *A. listoni*. CO₂ returned to a smaller extent. On 22.xii. oxygen again fell, and pH crossed the neutral point to 6.9, with a rise in CO₂ that gradually increased for a month subsequently. *A. listoni* dropped out, to appear again with another rise in oxygen on 19.i.25. Meanwhile, on 6.i., *Spirogyra* and *C. bitaeniorhynchus* had appeared. A solitary *Dixa zeylanica* had been carried in from the irrigation-channel, but it is not easy to explain how *Culex minutissimus*, a moving-water species that was not in the channel at this time, came to be associated with *A. sinensis*, a typical standing-water species that was breeding steadily in the last half of December and all January, during which month conductivity rose to a value not attained since the field was transplanted. The grain was now set, and drying-off commenced on 2.ii., with a sharp fall in oxygen and CO₂ that removed all larvae except those of *C. bitaeniorhynchus*, which was still to be found sparsely in a patch of *Spirogyra* that had persisted in one corner since the beginning of January, probably over a place where seepage from the channel was occurring. The fall in oxygen culminated in its complete absence on 24.ii., on which date a solitary *bitaeniorhynchus* larva was found some two feet away from the *Spirogyra*, having probably left the dying alga in search of more favourable conditions. The final examination, on 2.iii., had to be made in another part of the field, as the spot generally examined was now merely damp. This examination was made in a relict puddle just outside the stand of paddy, about 3 inches in depth, and is not comparable with the immediately preceding examinations, as the much higher pH and high oxygen-content show, though conductivity and CO₂ are not greatly altered; this carries the story through to the puddle conditions found at the commencement of the year's investigation.

I have thought it worth while to describe the changes in a rice-field at some length, as there is, in Ceylon at least, such a prevalent opinion that rice-fields are a bad source of malaria. The result of a year's careful investigation shows that the only malaria-carrying species breeding in them at all regularly is *A. listoni*, for though *A. maculatus* is not unknown, it has only been carried in from the irrigation-channel whenever it has occurred, and then is obviously out of its element and unlikely to survive. It is noteworthy that Watson (1921, p. 209) also found *A. aconitus* (the Malayan representative of the *funestus* group, to which *listoni* also belongs) in rice-fields, but only where there was running water. This, as will be seen from the present results, is associated with a considerable oxygen-content, and it is only in the presence of much dissolved oxygen that *listoni* appears in rice-fields. If, therefore, steps are taken to keep the water-level on rice-fields low, and with it the oxygen-content, the only malaria carrier that is capable of breeding freely in the fields will be deterred from doing so.

Now Harrison & Subramania Ayyar (1914) have shown that there is on the surface of the soil in rice-fields an organised film that evolves considerable quantities of oxygen, which is utilised in the aeration of the roots of the crop and without which rice, not being a true aquatic plant, could not grow (*id.*, 1913). This oxygen is produced by the oxidation of the methane, etc., evolved from the soil, the CO₂ thus produced being in turn decomposed by the green algae present in the film with liberation of gaseous oxygen. This oxygen is used for the root-aeration. It is therefore obvious that the amount of dissolved oxygen in the irrigation water is of primary importance. If it is low, it will be so drawn upon by the surface-film organisms for their methane-oxidisation that insufficient will remain to support *A. listoni*, for apparently the final alga-evolved gaseous oxygen is directly utilised by the paddy roots; if there is an excess, enough will remain to satisfy the requirements of the Anopheline. The results of the past year's examination of this field indicate that sufficient excess for *listoni* can only occur in the presence of a considerable depth of water, and the maintenance of this necessitates running water through the field continuously. Not only does this practice, which is very common in Ceylon, thus lead to the fields becoming a breeding-ground for a malaria-carrying species, but it is bad agriculture and wasteful of water. The only thing which can be said in its favour is that it tends to lessen the depredations of rats (mainly *Gunomys gracilis*, Nehr.), which do heavy damage in the narrow, often scrub-surrounded rice-fields of the Ceylon sub-montane zone in the presence of insufficient depth of water to discourage their movements among the growing paddy. However, it should not be impossible to evolve a method of dealing with these pests without turning the fields into a malaria breeding-ground.

XI. On the Possibility of Biological Control.

Our present methods of mosquito control are wasteful and expensive, whether they be drainage or oiling. According to Watson (1921), the Seafeld Group of rubber estates, in Malaya, spent \$79,256 between the years 1911 and 1919 on the control of *A. maculatus* by the former method; and though oiling is initially cheap, its effects are purely transitory and demand constant supervision if satisfactory results are to be maintained. On one estate in the writer's sanitary charge anti-malaria measures of this nature cost about Rs. 7 per coolie per annum.

Both systems are financially justifiable and cost less than the disease, but with Nature continually demonstrating that mosquitos can be naturally controlled without our help, we look enviously towards these costless methods. The whole object of the mosquito research of to-day should be the understanding and application of biological methods of control.

As with so many other points concerning malaria, this was first envisaged by Watson, who as long ago as 1910 found that the Anophelines of two groups of rice-fields differed in specific composition, one containing dangerous and the other innocuous species, and in a public lecture (Watson 1910) rhetorically asked: "Now, why do these vary? Clearly on account of something in the water; and it can be easily imagined that only a small change would assimilate the Bukit Gantang water to that of the Krian rice-fields, and then malaria would disappear from Bukit Gantang too. I believe that in this way a great anti-malaria method will be evolved, and I can look to the time when we will be able to play with species of *An p eles*, say to some 'Go,' and to others 'Come,' and abolish malaria with great ease, perhaps at hardly any expense. Drainage schemes may become things of the past, and future generations may smile to think how their ancestors, who, thought they were so clever, burned the house to cook the pig."

Again, to Watson are due observations on what he calls the "felted alga," the presence of which in water always denotes absence of *A. maculatus*. It is an extreme pity that this growth has not been identified, but Watson states that it follows oiling,

occurs in streams where clothes are washed, can be induced by solutes from certain timbers, or may apparently appear naturally.

Now the absence of larvae from streams used for washing clothes has also been noted by MacGregor in Mauritius, and I can confirm the observation from my own experience. Some preliminary experiments made here indicate that the addition of about 1 per cent. by volume of a saturated solution of common soap will move a hard water from pH 7.3 to 9.6. Toilet soaps contain much less free alkali and have not the same effect on the concentration.

But it seems likely that the anti-mosquito effect of washing is not due to a pH change. A cheaper source of alkali than soap is fresh wood-ashes, the addition of which to water will also bring the pH to 9.6. In a preliminary experiment on this, in which a lot of *A. maculatus* in all instars was equally divided and placed (a) in their own water at pH 7.0 changed daily, and (b) in ash-water at pH 9.6, there was no more mortality in a week in (b) than in (a). Further, in nature, streams in which washing is done are not at such high pH values as 9.6, though washing pools may be, for in these the soap accumulates, though probably never to anything approaching a 1% concentration. I examined a large pool of this nature at Trincomali, typical of the pools seen throughout the Plains of India, and found it to be at pH 9.0; larvae were absent.

The effect of oiling on pH is easily understood, if it is a fact that oil will only spread in presence of an —OH group, as noted from Dr. Hacker's unpublished work on page 211. Some preliminary experiments made with fuel-oil, which spreads very badly indeed, showed that the addition of this to water, even after a thorough shaking, results only in very slight changes in concentration (e.g., 7.2 to 7.6), but the "anti-formica" findings quoted on page 211 indicate that, with a properly spread film, very high values may be obtained. However, here one has to consider the possible solutes from wooden table-legs also affecting the water, a point which carries on to Watson's observation of a freshly cut tree lying in a stream and producing his "felted alga" in the water below it for a long distance.

The whole subject of the effects of soap and oiling, as of other organic contaminations, on the pH of water is one demanding proper quantitative investigation, for which as yet time has not afforded me opportunity. I do not think, in face of the ash-water results mentioned above, that any pH change so induced acts directly on the larvae. It is far more likely that in rising to high values it inhibits the growth of the food organisms, as visible in the change in the macroscopic algae quoted by Watson.

Lamborn (1922, p. 17) attempted to discover the factor which changed when sunlight is admitted to previously shaded water, inducing the Anopheline fauna to change from the dominance of the malaria-carrying *A. umbrosus* to that of the harmless *A. barbirostris* (vide Table V of his paper). In Table VI he gives two water analyses, in one of which *umbrosus* was dominant, while in the other it had been replaced by *barbirostris* as a result of removal of shade. Two factors differed. In the presence of *umbrosus* there was only half as much albuminoid ammonia and less than 40 per cent. of the total solids in solution; but unless the incidence of sunlight resulted in great evaporation, which is not stated, these changes could hardly be due to the admission of light, and I think that the *umbrosus-barbirostris* factor was missed.

In a further experiment to test the possible attraction-effect of odour on ovipositing females Lamborn attempted to mask the odour of a jungle pool, favoured by *A. umbrosus*, by the addition of formalin. No result was obtained, larvae being as numerous afterwards as before.

The writer repeated this experiment, but a suitable pool not being available, water in which cuttings of ornamental crotons had been standing for two weeks was used. This water was brownish (exactly the shade of thymol-blue at pH 8.2), with

some pulpy, dissolving, submerged leaves. It had a not very strong, but unpleasant odour. The pH was 6.4 (6.9 residual), and conductivity 784. The water was thick with Ciliates and Turbellarians, with numerous unicellular yeast-like bodies. No larvae were present at the commencement of the experiment.

The water was divided into two portions, to one of which 1 per cent. of strong formalin (40 per cent.) was added. Subsequent events were as shown in Table XV. From this it will be seen that the treated portion had consistently a slightly higher pH, but that the formalin in the water not only almost entirely inhibited oviposition (*S. albopicta* being the species concerned), but further rendered infertile the few eggs laid on it.

TABLE XV.

Effects of Addition of 1 per cent. of Formalin to Water containing Vegetable Solutes

	A.—Control.			B.—Formalined		
	pH	Eggs laid	Remarks	pH	Eggs laid	Remarks.
6 XII ...	6.4	0	Sour odour.	6.4	0	Faint formaldehyde odour with trace of original odour also.
7 XII. ...	7.4	21		7.6	4	Infertile, did not turn black.
8 XII ...	8.0	10		8.0	0	
9 XII ...	8.0	40		8.0	0	
10 XII ...	8.0	10		8.2	0	
11.XII. ...	8.4	5		8.6	0	
12.XII. ...	8.4	28		8.6	0	
13 XII. ...	8.4	0		8.6	0	
14 XII. ...	8.5	0		8.8	0	
15 XII ...	8.6	21		8.6	7	Still some formaldehyde odour. Infertile eggs, did not blacken.
17.XII. ...	8.7	0		—	0	
19 XII. ...	8.5	26	Absolutely odourless.	8.6	0	A very faint odour.
20.XII. ...	8.7	18		—	0	
22.XII ...	8.6	15	Some odour.	8.8	0	Some odour, similar to A.
24.XII. ...	8.6	20		9.0	0	Drying up
		214	All fertile. Hatched in tap water.		11	All infertile.

Far more important, I think, than its mere odour (which was from the first so slight that the original odour could be detected through it, whilst latterly such odour as existed was the same in both lots) was the effect of the formalin in inhibiting oviposition. *In the water containing formalin the plankton was all dead within two hours of the addition of the chemical.* This, I think, was the inhibiting factor, and in Lamborn's experiment evidently insufficient formalin was added to kill off the plankton of the pool.

In this connection a recent paper by Rudolfs (1924) is interesting, though his results are presented in a form very hard to follow. He comes to the conclusion that food supply for larvae is the main cause governing breeding, and that this seems to be dependent on the chemical composition of the water, which, *per se*, does not prevent the breeding of certain species, unless it contains definitely toxic substances, such as chlorine and the sulphates of iron and aluminium. He states that in several cases the death of larvae in his laboratory could be directly traced to the exhaustion of the food supply.

Now Watson (1921, pp. 344-349) has shown that the curve of malaria caused by *A. maculatus* has its maximum in Malaya in the month of May. In Ceylon examination of statistics on estates in the sub-montane zone, where this species is the principal carrier, confirms this, but the peak of the curve may occur as late as July, or even August. In any case, the months from April to August are the unhealthiest of the year; whereas in Ceylon malaria caused by *A. culicifacies*, and in Malaya that caused by *A. umbrosus*, have maxima at other seasons. A "fever-season" from April to August connotes an Anopheline abundance from February to June. The variability of the peak of the curve in this Island, as compared with Malaya, seems to be due to the part played in Ceylon by *A. listoni*, which has its maximum abundance in April to June, as against February for *A. maculatus*.

In figure 8 are plotted the monthly percentages of all larvae of *A. maculatus* and *A. listoni* taken by this laboratory, and of all *Spirogyra* records, together with the average rainfall curve of an estate in the area where these two species are the only malaria-carriers of importance.

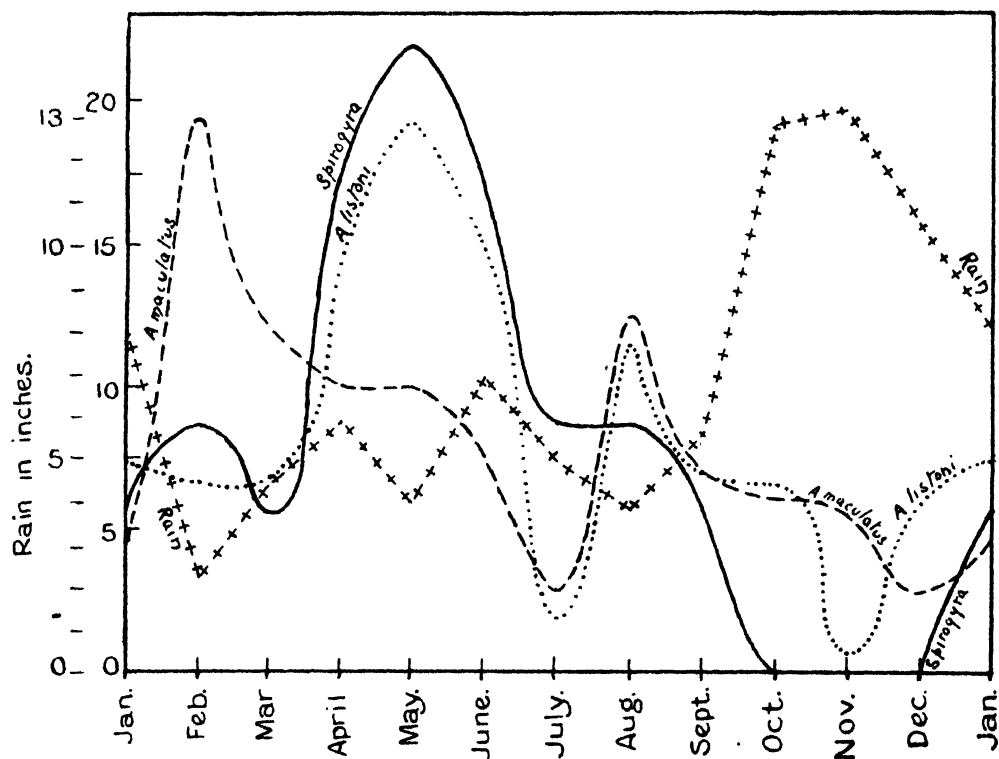


FIG. 8. Percentage curves for each month of *Anopheles maculatus*, *A. listoni* and *Spirogyra*, with average rainfall in the Ceylon sub-montane zone.

¶The February maximum of *maculatus* and the subsequent maximum of *listoni* are well brought out, with the decrease of both species ensuing on the north-east monsoon rains at the end of the year; but the interesting point is the secondary maximum of both species which occurs in August. Now the *Spirogyra* records are very few as compared with the mosquito figures, and are thus not nearly so reliable, but the curve for the genus shows two maxima, in February and May respectively, which correspond with the maxima of *maculatus* and *listoni*, and though it has not another rise in August corresponding with the secondary maxima of the

Anophelines, the curve is so flattened at this point that it is possible that this really occurs. Thereafter, the genus disappears until the end of the year, and the abundance of Anophelines falls, *A. listoni* however commencing to increase again before the alga.

Now neither species of Anopheline is dependant on *Spirogyra*—they are both at least as often found away from it as associated with it, but the apparent similarity of the curves is emphasised because, though there is no direct association with *Spirogyra*, there very probably is with Diatoms and perhaps Desmids, and it is not improbable that these, concerning the monthly variation of which nothing is known, follow a curve similar to that of *Spirogyra*.

Now it is well known that in the sea the spring Diatom maximum is followed, after a period of scarcity, by a secondary rise in the autumn. This is clearly shown in the excellent tables and diagrams recently published by Johnstone, Scott & Chadwick (1924). Atkins (1923a), shows that the vernal maximum results in a great depletion of previously accumulated phosphate, and though he does not deal specifically with the secondary, autumn rise, he shows (table vii and fig. v) a re-accumulation of phosphate in the lower water layers in August. Phosphate is shown in the same paper to be the limiting factor in Diatom growth.

Dealing with fresh water, Atkins & Harris (1924) show a similar state of affairs. A high accumulation of phosphate occurs in winter, followed by the vernal phytoplankton outburst, with almost complete phosphate deprivation, on which the mid-summer stagnation period ensues. About July there is a secondary rise in phosphate, which results in, and is quickly used up by, a "renewed outburst of photosynthetic activity."

Now, it is extremely dangerous to argue from the Temperate to the Tropic Zone, but the curves indicate that something similar to European conditions may possibly occur in respect of the phosphate content of fresh water in the Tropics, and that phosphate content, through controlling the algal, and mainly the Diatom prevalence, actually controls the amount of breeding of at least *A. maculatus* and *A. listoni*. Should further research along the lines indicated (the first being the accumulation of definite data on larval food materials) prove this to be the case, there is opened up a line of biological control by attacking the algae with copper sulphate. However, as shown in Section X, this method would be inapplicable in respect of waters which at any point further down their course were used in rice-field irrigation, on account of the imperative necessity of non-interference with the organisms of the surface-film on the soil of such fields. However, another method of controlling *A. listoni*, the only malaria-carrier commonly breeding in rice-fields, is indicated on pages 240-241.

XII. Summary and Conclusions.

1. Natural waters in Ceylon extend in pH range from 5.4 to 9.2, but mosquito larvae in general are only found between pH 5.8 and 8.6. Species living in moving water have wider tolerances than those of standing water, and the former extend further into acidity, and the latter into alkalinity, respectively. Anophelines have wider tolerances than Culicines.

2. The measurement of "residual" pH, *i.e.*, the value after bringing the water into gas-equilibrium with the air, is shown to be of value. Natural-water breeders are thus found to be intolerant of any acidity not caused by CO₂.

3. The natural-water breeders are all found in water with C $\times 10^6$ of $<1,000$. The artificial-water breeders extend their range into much higher concentration. There is the possibility of the existence of biological races of natural-water breeders in brackish water, but in inland waters the moving-water species have their optimum at <300 , and the standing water species at <500 . The former, again, have wider tolerance limits. Conductivity has been measured at 25° C.

4. There appears to be no sharply limiting factor in dissolved oxygen, but waters in which this is low are not favoured by Anophelines. In rice-fields the presence of *A. listoni*, the only malaria-carrier commonly breeding in them, is shown to be dependent on a considerable amount of dissolved oxygen, and methods for avoiding this are discussed.

5. Saline ammonia in amounts of less than 1 p.p. million are inhibitory to natural-water breeders, especially Anophelines.

6. The "association-unit" hypothesis of Hacker is shown to be well founded.

7. There is shown to be a feeding-association of certain mosquitos, mainly Anophelines, with certain algae, on the presence of which that of the mosquitos probably depends.

8. The pH of the various parts of the gut in larvae is tabulated. There is shown to be very little difference between various species. In all, the mid-gut is very alkaline, the other parts less so. Diseased states seem to be related with decreased alkalinity.

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SUGAR-CANE MOTH BORERS (*DIATRAEA* SPP.) IN BRITISH GUIANA.

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The writer had exceptional opportunities for studying sugar-cane moth borers while engaged as entomologist to one of the most progressive cane-growing concerns in British Guiana from September 1922 until January 1925. The observations and data that follow refer to some three thousand acres of typical cultivation situated on the west bank of the Berbice River, nearly opposite the town of New Amsterdam, in which locality the borer pest probably reaches its maximum in destructiveness.

Owing to the occurrence of *Castnia licus*, Fabr. (the giant moth borer), the larvae of the Pyralid moths of the genus *Diatraea* are distinguished as "small moth borers" in British Guiana, and are represented by three species: *D. saccharalis*, Fabr., *D. canella*, Hmps., and *D. lineolata*, Dyar. Another Pyralid, *Elasmopalpus lignosellus*, Zell., is occasionally found boring in cane-stalks in the field; the writer calls this the "lesser moth borer." The present paper refers entirely to the small moth borers of the genus *Diatraea*.

Previous Literature on the Subject.

Cane borers in British Guiana were described and the planters warned of their danger to the Colony's staple industry by Miss Ormerod (14)* as far back as 1879. In 1900 H. Maxwell Lefroy published a detailed account of *Diatraea saccharalis* in the West Indies, and this paper (11) still, in the writer's opinion, remains the standard one upon the subject. Within the Colony J. J. Quelch and H. W. B. Moore have each done excellent pioneer work since 1910, and one paper (15) by the former can be considered the best and most interesting account of the pest in British Guiana. Moore's monthly and annual reports (12) to two of the largest sugar companies in the Colony contain much information of value to planters as well as to technical workers upon the borer problem. More recently G. E. Bodkin and L. D. Cleare, Jr., have added to our knowledge of the pest and means for its repression, their findings being recorded for the most part in the official publications of the Science and Agriculture Department, Georgetown, Demerara. Cleare, however, published an extended account (6) of *Diatraea*, largely based on his work upon the same plantations as the present writer's, carried out for eighteen months prior to the latter's arrival in the Colony in 1922; this paper, besides containing many original observations, summarises to its date practically all that was known of *Diatraea* in British Guiana. The present paper discusses the major points which came to the writer's notice during his sojourn in the Colony, and brings forward a few aspects which it is believed have not yet appeared in print, and which, it is hoped, may assist other workers engaged in similar problems elsewhere.

Species of Borers concerned and their Food-plants.

Of the three species of *Diatraea* known to attack sugar-cane in British Guiana, only two, *D. saccharalis* and *D. canella*, can be considered as being of economic importance. The third species, *D. lineolata*, seldom attacks the crop, and when it does, it confines its injuries to young canes; the writer has never seen its larva in mature cane-stalks. Regarding the two major pests, their numbers are about equal, although at any given season there may be a preponderance of one species in any one locality, whilst elsewhere the other species would be more abundant. On the other hand, in

* Numbers in parentheses refer to "Literature cited" at end of paper.

any given locality the relative abundance of one species may be greater at one time of the year than another, when the other species would predominate. It may be observed, however, that in general *D. canella* is more a pest of young cane-shoots than is *D. saccharalis*, the greatest damage due to the latter being that which it inflicts upon ripening and mature cane-stalks. Neither these two insects, nor *D. lineolata*, confine their attentions to sugar-cane, the latter species, indeed, feeding for the most part upon wild native grasses, attacking the cane crop only in exceptional circumstances. The characteristic "dead-hearts" caused by the presence of the larvae of *D. saccharalis* have been observed in maize and in rice, the former plant sometimes harbouring the larvae of *D. canella* as well. No cases are on record, however, of material losses to either the maize or rice crop through attacks by sugar-cane borers.* Both *D. saccharalis* and *D. canella* breed in abundance in the stalks of several wild graminaceous plants, the most important of these alternative food-plants being the so-called "razor-grass" (*Paspalum virgatum*), which occurs ubiquitously upon the "danis" which separate one group of cane-fields from another, and in abandoned lands in the vicinity of cultivation. An average stool of this grass may consist of anything up to 75 shoots, and not infrequently 50 per cent. of these will harbour borers in various stages. The common and troublesome Pará grass (*Panicum barbinode*) may sometimes show the signs characteristic of borer attack, but in a general consideration it is the pernicious "razor-grass" that so greatly handicaps the control of *Diatraea* on most sugar-estates in the Colony.

Life-history of the Borers.

The life-cycles of the two major species of *Diatraea* were worked out in the laboratory, following the system described by A. H. Rosenfeld and T. C. Barber in their excellent paper (16) upon *D. saccharalis obliterellus*, Zell., in Tucuman, Argentina. Field experiments made as checks served to show the data obtained in the laboratory to be fairly reliable. Technical descriptions of the various stages would be out of place in a paper of this nature, but a brief résumé of the salient features of the life and habits of the two species of borers may be of interest.

The eggs are deposited upon the upper surface of the leaves of the food-plant in clusters of from ten to sixty (average about thirty-five); being flat, broadly oval in outline, and overlapping one another like the scales of a fish. The eggs of *D. saccharalis* hatch after about 7 days, whilst those of *D. canella* require about 36 hours longer for their development. The newly hatched larvae would seem to make their first meal upon the epidermis of the leaf, but within 24 hours will have tunneled into the stalk if the shoot is young and tender or into the midrib of the leaf if the cane is nearing maturity; a favourite haunt of very young larvae is between the leaf-sheath and the stalk, where nearly always there is a sufficiency of tender tissue for their requirements. As growth ensues the larvae cast their skins, and during the larval period five such moults occur, the final change being to the pupal stage. The entire larval period is spent in assiduously feeding upon the inner parenchymatous tissue of the growing cane-stalks and requires from three to five weeks for its completion. A curious habit of half-grown borers, most conspicuous during rainy weather, is that of leaving their tunnels and boring the same stalk at another point or else migrating to another stalk. For pupation a tunnel is made to the surface of the stalk terminating in a sort of operculum cut in the rind, which can later be readily pushed aside by the emerging moth. The larva, on completing its development, widens a portion of its burrow and lines this "cell," as it may be termed, with a few layers of silken threads, and after a resting or pre-pupal period of about 36 hours, changes to the pupal state, which occupies 8 days. The adult moths are seldom seen in the field owing to their protective colouration and retiring habits; occasionally,

* The common rice borer in British Guiana is *Scirpophaga albinella*, Cram.

however, they show themselves for a few moments in daylight when the trash banks between the rows of canes are disturbed. Flight commences at dusk, and mating and oviposition are carried on at night. The moths exhibit a decided phototropic response, which appears to be more pronounced in the male than in the female, the latter sex forming but a small proportion of the moths collected at trap-lanterns put into fields at night.

Damage done by the Borers.

This may for convenience be discussed under the following heads :—(1) Injuries to the seed-piece ; (2) injuries to the young shoots—"dead-hearts" ; and (3) injuries to the ripening and mature stalks.

(1) *Injuries to the seed-piece*.—The upper portion of cane-stalks being generally more heavily infested than the lower portion, where the rind is harder (this being conspicuous in British Guiana, where canes are "trashed" twice during their growth), and "tops" being universally used for seed, it follows that a large proportion of the latter are injured by the pest—indeed, on several occasions 100 per cent. infestation of seed-cane had been observed, the average of such infestation, however, being around 75 per cent. of all seed planted. This applies to injuries visible in the rind, not all of which need be due to current infestation, but often to borers that have completed their development and emerged some time previously. From data gathered over three planting seasons the writer is prepared to assert that not less than 20 per cent. of all seed planted contains living borers in various stages of development. In addition to the loss in germination due to the actual destruction of the buds, there is a greater one due to the rotting away of the seed after it has been planted, through bacterial and fungoid agencies which have gained entry by way of *Diatraea* injuries. The most prevalent of these troubles is the so-called "pineapple disease," due to the fungus *Thielaviopsis paradoxa* (de Seynes) v. Höhn, the presence of which often necessitates the replanting of a large portion, sometimes as much as 30 per cent. of the seed. The treatment of seed-cane with a ten-second immersion in Bordeaux mixture (4.4.40 formula) did much to reduce this loss, and the writer devised a motor-driven machine for dealing with large quantities of tops for planting purposes.

(2) *Injuries to the young shoots ; formation of "dead-hearts."*—It is proposed to distinguish the early infestation of young fields by borers that have entered the shoots from either the seed-piece in the case of plants or the stubble in the case of ratoons as primary borer infestation, whilst that caused by borers hatching from eggs laid subsequent to planting or the last cutting of a field may be known as secondary borer infestation. In ordinary circumstances primary infestation of 5 per cent. of all the seed is not unusual, and occasionally this form of infestation may be as much as 20 per cent. of all shoots above ground. It will readily be understood that the size of a borer aids in deciding whether any dead-heart is due to primary or secondary attack, for, obviously, if a 4-weeks old larva or a pupa is found in a 3-weeks old shoot, the infestation must be primary, whilst a 1- or 2-weeks old larva in the same circumstances must be of secondary origin. Secondary infestation of a field may be due to eggs deposited by (a) moths which have developed primarily in the same field, or (b) moths migrating into the field from outside, such outside sources of infestation being limited to neighbouring cane-fields, or patches and belts of razor-grass (*Paspalum virgatum*).

Apart from any direct loss in stand due to the presence of large numbers of dead-hearts in a field, there can be no doubt that the health of the stools is seriously impaired through the rotting away of the injured tissue, forming media for the growth of fungous and bacterial forms. The custom of removing dead-hearts from the fields is one calculated to do immense good, not only by the partial control of the pest thereby effected, but by the fact that the clean cuts make for more rapid healing of the injured tissue, and that the subterranean buds are stimulated into growth.

(3) *Injuries to the ripening and mature stalks*.—Whatever the losses sustained through other forms of injury, there can be no doubt that the most serious is that done to the sugar-bearing tissue when ripening and mature sugar-canes are attacked by *Diatraea*. Practically no research has been done in British Guiana to ascertain the monetary loss through such forms of damage, but such work done in Barbados (3), Louisiana (1), and Porto Rico (19), would show that besides a direct loss in weight due to borer attack, there is a reduction in the quantity and quality of the juice, the latter manifested by lower brix, sucrose, and purity figures, with a correspondingly higher glucose ratio; the fibre content has been found to be higher in bored than in clean canes. The foregoing refers, of course, to "millable" canes, no account having been taken of the large number of canes so heavily infested that they are left in the field and are not sent to the mill for grinding, having either dried up through rind disease (*Melanconium sacchari* [Cke.] Mass.) following upon *Diatraea* injury, or the weevil stalk-borer (*Metamasius hemipterus*, Linn.) converting the stalk into a mass of chewed-up fibrous matter, this pest being secondary in attack after *Diatraea* has punctured the stalks. The writer has seen fields with a dead loss of 25 per cent. of the crop due to *Melanconium*, and as high as 30 per cent. of all the canes in some parts of the fields lost through *Metamasius*, both losses being due in the first place to *Diatraea*. There is a conspicuous difference in the *modus operandi* of *Diatraea canella* and *D. saccharalis* when attacking "high canes," for whereas the former makes long, vertical tunnels through two or more successive internodes, the latter species eats transversely across the stalk, severing two-thirds or more of the vascular system, and canes so injured are readily snapped by labourers passing down the rows or by atmospheric agencies such as wind or heavy rain. One has only to go through fields a few days before they are cut to realise the tremendous number of fallen and broken canes, many of which will have commenced to throw out adventitious shoots and roots at the nodes in the lower part and dry up in the upper part above the severance of the stalk. It has been estimated by Mr. Cleare (5) that in 1917 the losses due to *Diatraea* represented about 20 per cent. of the value of the sugar crop of the Colony; the present writer agrees with Mr. Cleare that this figure is well on the conservative side.

Calculating the Final Infestation of Cane-fields.

By "final infestation" is understood the infestation of any block of cane at the time it is harvested, contrasted with infestation at any earlier period in its growth. In plantation entomology perhaps more than in experiment station work, a record of the final infestation of fields is of the greatest importance, not only in that, once a standard has been arrived at, the status of the pest can be ascertained for any time or locality, but such data, collected over long periods, reveal any annual increase or decrease over individual areas, enabling the entomologist to follow the progress of his control work.

In the United States, where Holloway and Loftin have studied the *Diatraea* problem of Louisiana cane-fields for many years, the standard now adopted (10) for estimating the abundance of the pest is to count 100 cane-stalks at random in a field and separate the injured from the clean canes, the number of the former representing the per cent. of final infestation. From data published in 1919 (9) the infestation over the Louisiana sugar-belt was ascertained to be 58.2 for the six years 1912-1917. It is stated that "In 1912 the general average was 50.4 per cent., in 1913 it was 52.4 per cent., in 1914 it reached the high figure of 73.9 per cent., while in 1915 the average sank to 51.5 per cent. The average was again high in 1916, being 75.5 per cent., but in 1917 it was 48.8 per cent., the lowest during the six years." The writer is unable to trace Louisiana records for recent years, but an idea of the

status of *Diatraea* infestation in British Guiana may be gathered from the following, based on a similar method of calculation :—

TABLE I.

Crop period.	Estate " A. "		Estate " B. "	
	No. of fields.	Average final infestation.	No. of fields.	Average final infestation.
Autumn, 1922 ...	46	67.2	45	86.4
Spring, 1923 ...	39	80.3	37	82.7
Autumn, 1923 ...	42	85.7	49	80.8
Spring, 1924 ...	14	95.9	16	88.3
Autumn, 1924 ...	16	93.6	—	—

It is believed that in no other country where sugar-cane is grown does *Diatraea* attain such high percentages of infestation. During the writer's sojourn in Berbice, 272 separate final infestation counts were made, necessitating the examination of 27,200 cane-stalks : in 4 instances only was the infestation 50 per cent. or less, in 8 instances between 51 and 60 per cent., in 21 instances between 61 and 70 per cent., in 62 instances between 71 and 80 per cent., in 115 instances between 81 and 90 per cent., and in 62 instances between 91 and 100 per cent.

During the crop periods between October 1922 and May 1923, the writer followed the system inaugurated by Mr. Cleare, which was a slight modification of that proposed by Holloway and Loftin, by making the counts on canes which had been cut and were ready for loading, the examinations being made of twenty stalks at five well-distributed points in each field. In this system the number of joints (internodes) in each stalk was counted, as well as the number of these joints showing visible borer damage ; the proportion of the latter in the former giving the per cent. of joint infestation. It seldom happens that canes are cut entire, hence it is reasonable to suppose that many of the pieces counted as clean might well be merely clean portions of partly infected stalks ; this led to the check being made inside the field upon standing cane specially cut for the purpose in whole lengths, the stalks being taken consecutively as they came to the hands of the cutter, and five such examinations of twenty stalks each being taken in each field. A considerable margin of error was eliminated by the adoption of this method at the commencement of the autumn crop of 1923.

Whilst a note of the stalk infestation is always of interest, it is felt that this cannot be accurate within any reasonable limits when only 100 canes are taken in a field of, say, 18 acres (the standard in Berbice), although average figures based on several fields may be fairly reliable. The writer therefore proposes that the joint infestation be adopted as the standard in calculating the status of *Diatraea* ; for not only is the margin of error greatly reduced (there was a maximum divergence of only 1.4 per cent. above and below the average of 12.1 per cent. joints infested in ten checks—1,000 canes—made in one field, whilst seven of the checks were found to approach the average within 0.5 per cent.), but also such figures conform more closely with fluctuations in the quality of the juice as revealed in the chemical laboratory. A field with, say, 80 per cent. of the canes bored may show a joint infestation varying all the way between 12 and 25 per cent., or, to put it differently, although the actual number of canes injured by borers may be identical in two fields, the number of joints attacked on each cane may be greater in one field than in another. In the spring of 1923 a field was harvested which revealed the following final infestation : stalks 87 per cent., joints 30 per cent. ; another field cut the same season showed

stalks 98 per cent., joints 15 per cent. Now, if the infestation of stalks is used as a basis for calculating the losses sustained in these fields, it follows that the second field was the more highly injured, but the writer asserts that the damage in the first field was approximately twice as great as that in the second, in spite of the smaller percentage of canes actually bored. These observations are not intended as a criticism of the standard which has been adopted by the Committee on Estimating Insect Abundance of the American Association of Economic Entomologists, but are suggested as an improvement upon the method at present in vogue.

Final Infestation of Cane-fields.

Based on the foregoing, records were made of practically all fields cut between autumn, 1922, and autumn, 1924, on Estate "A", and between autumn, 1922, and spring, 1924, on Estate "B." In the following table, however, it is considered desirable to record only those fields in which the improved method of gathering the data was adopted :—

TABLE II.

Crop and month.	No. of fields examined.	Per cent. of infestation of stalks.			Per cent. of infestation of joints.		
		Max.	Min.	Ave.	Max.	Min.	Ave.
Estate " A."							
<i>Autumn, 1923—</i>							
October ...	19	97	66	83.8	17	7	11.0
November ...	5	90	69	82.5	14	8	11.0
December ...	9	97	74	86.5	15	12	14.0
January ...	9	99	80	90.0	25	12	17.5
<i>Spring, 1924—</i>							
March ...	14	100	90	95.9	24	11	17.1
<i>Autumn, 1924—</i>							
October ...	6	99	85	90.8	28	14	19.3
November ...	10	100	95	96.5	24	15	17.9
Estate " B."							
<i>Autumn, 1923—</i>							
October ...	29	90	63	81.9	27	7	18.6
November ...	5	89	75	79.6	19	11	14.4
December ...	8	85	74	79.0	23	12	16.4
January ...	7	91	77	82.7	22	16	19.0
<i>Spring, 1924—</i>							
March ...	16	99	77	88.3	27	14	19.6

During the period covered, the lowest joint infestations recorded were 7 per cent. (two fields, with 69 per cent. and 72 per cent. stalk infestations respectively), while the highest joint infestation was 28 per cent. (one field, with 95 per cent. stalk infestation). Of the 137 examinations made, in 13 instances the joint infestation was between 7 and 10 per cent., in 45 instances between 11 and 15 per cent., in 49 instances between 16 and 20 per cent., in 25 instances between 21 and 25 per cent., and in 4 instances above 25 per cent.

Effects of such high Infestation.

It has already been mentioned that practically no research work has been done in the Colony to estimate the approximate losses due to moth borer attack. The writer, however, was able to trace from estate records certain unquestionable relationships between the final infestation and the number of tons of cane required to produce

one ton of sugar, joint infestation only being the basis for calculation. When the figures for individual fields were compared, little relationship could be found between the two factors, but when based on averages for all final infestation records over the period spring 1921 to spring 1923 such relationship becomes apparent :—

TABLE III.

Infestation of joints between	No. of fields examined to get the average.	Tons of cane required to produce 1 ton of sugar.
5 per cent. and 10 per cent. ...	72	10.226
11 per cent. and 15 per cent. ...	38	10.586
16 per cent. and 20 per cent. ...	34	11.904
21 per cent. and over ...	16	11.924

Note.—The final infestation records for the crops from spring 1921 to spring 1922 were made by the writer's predecessor, Mr. Cleare.

Whilst there are many factors other than the prevalence of borer infestation that are responsible for fluctuations in the number of tons of cane necessary to produce a ton of the final product, *e.g.*, the incidence of other insect pests, general improvements in both field and factory, etc., the writer feels that these cannot entirely account for the following :—

TABLE IV.

Year.	Average final infestation of joints.	Tons of cane required to produce one ton of sugar.
1921 ...	22.00	12.167
1922 ...	10.90	10.309
1923 ...	9.90	9.951

The Factors which influence the Prevalence of Borers.

A proper understanding of all the factors which affect the relative abundance of *Diatraea* requires a longer period of study than the writer was able to devote to this important aspect ; nevertheless, certain observations bearing upon this subject may be worthy of record. The principal factors concerned may be classified as follows :—

A. Artificial.

1. The position and environment of the area under cane.
2. In plant fields the infestation of the seed used ; in ratoon fields the infestation of the stubble left in the ground at last cutting.
3. The relative sanitary condition of the fields during their early growth.
4. The burning of all fields previous to cutting.
5. Class of canes—plants or ratoons.
6. Variety of cane.

B. Natural.

7. Meteorological conditions.
8. Incidence of natural enemies.

1. *The position and environment of the area under cane.*—J. J. Quelch was the first who, in his efforts to stimulate interest in the borer problem of British Guiana, pointed out the danger that lies in the indiscriminate scattering of fields of all ages over an estate. It generally happens that any newly planted or freshly cut area is bounded on at least two sides, more often three, by canes of three, six, or more months' growth, which form a ready source of initial secondary infestation. While admitting that to alter this state of affairs would require changing present estate methods, the writer feels that much could be done to facilitate borer control in British Guiana if the relation between new fields and their neighbours was considered, and the former placed as far as possible in line with fields approximating them in age, rather than the other extreme. The eradication of cane-stools in abandoned fields, which harbour all manner of insect pests, from the vicinity of cultivation is especially desirable but is seldom carried out. The presence of the ubiquitous "razor-grass" in large blocks is frequently responsible for the migration of moths to young cultivation, and it is felt that there is little excuse for not cutting back and burning this grass at planting and cutting times, thereby destroying immense numbers of borers at a low cost, as well as giving an added protection to the young canes. This does not now apply to the estates familiar to the writer, where the management gladly co-operated in arranging for the systematic digging-out of the grass within a reasonable distance of the cultivation, which measure was practically complete over three thousand acres at the close of 1924. Rows of suitable trees and bushes (*Leucaena glauca*, Linn., being suggested), or even bamboos, would, as well as aiding in keeping down wild grasses, tend to act as wind-breaks, and prevent the otherwise rapid spread of borer moths from one section to another, and, moreover, would serve as sanctuaries for insectivorous birds.

2. *In plant fields the infestation of the seed used ; in ratoon fields the infestation of the stubble left in the ground at last cutting.*—In British Guiana the general system of planting is to employ as seed the top portions of crop canes, these being cut into lengths of three or four joints, these "tops" being put into the ground at an angle of about 20 degrees, with the upper eye exposed ; and it will readily be understood that any borers present in such "tops" are able to complete their development and escape. The writer was able to demonstrate that *under normal planting conditions* the tops germinate just as well when planted flat in a furrow and covered with a few inches of soil ; under these conditions the moths are unable to penetrate the layer of earth and perish. By far the best system, however, is to plant only seed known to be borer-free, and this can be done either by killing borers present in the seed or by selecting seed in which no borers are present. The question of killing borers in seed cane is one that has occupied the attention of entomologists in Louisiana, who advocate the soaking of the seed-cane in hot water (122° F.) for twenty minutes (8). Such a measure would hardly be practicable under conditions in Berbice, but Mr. Cleare's system of submerging tops under water at normal temperature for 72 hours would seem to present no obstacles in a country where water transport is the regular thing ; the seed is in any case carried in iron punts from one field to another, and it seems easy to sink these for a three-day period, and then pump out the water by means of a small motor mounted in a boat, which could be moved from one punt to another. Researches have so far not pointed to any chemical that could be used for killing borers in seed-cane, but the writer found that a ten-second dip in Bordeaux mixture greatly improved the stand of cane from injured seed. If seed-cane were drawn down at six months' growth from fields set aside for the raising of clean borer-free cane, there would be available a quantity of clean seed for planting, and such a system promises the best results of all.

In ratoon fields no practical means are available for removing borers from the stubble, but the cutting of the cane as near the ground as possible greatly reduces their number. The principal danger to ratoon fields is the employment of heavily infested seed for replanting or "supplying" ; on several occasions the writer has

been able to trace the sudden appearance of large numbers of dead-hearts in young ratoon fields to this source, especially after a few days' rainy weather, when the larvae migrate from the replants to the young ratoon spring.

3. *The relative sanitary condition of the fields during their early growth.*—This heading refers to the often large amount of discarded seed and cane-stalks that are left lying about the parapets of fields; such fragments generally harbour *Diatraea* in all stages, often being discarded for that very reason, and these borers, on completion of their development, are able to infest the young canes. True, such refuse is sometimes collected and destroyed, but more often than not its presence is taken as a necessary evil.

The pernicious custom of replanting whole fields before the removal of the old ratoon stubble is a sure means of propagating borers, and Mr. Cleare (6) points out how borers present in the "old banks," as they are called, can form a source of ready infestation to the young plants.

4. *The burning of all fields previous to cutting.*—The writer is not prepared to discuss the pros and cons of this custom, which is universal in the Colony, and which is undoubtedly the chief reason for the high percentages of infestation that prevail everywhere. When a field is ready to be cut there are present large numbers of borers in the stalks, many of which are parasitised by Braconid wasps of the genera *Ipobracon* and *Microdus*, present in the canes in the pupal stage; large numbers of these parasites could finish their development and emerge between the time the cane is cut and its arrival at the mill were it not that they are destroyed by the hot atmosphere generated by these cane-field fires. The primary infestation of the ratoons that follow is therefore able to make headway and even become secondary before the influx of any larval parasites.

The tiny egg-parasites, *Trichogramma minutum*, Riley, which could otherwise be present to deal with the earliest eggs laid on the young ratoon spring, are practically exterminated locally by the fires, as they occur upon the leaves of the canes.

5. *Class of canes: plants or ratoons.*—Mr. Cleare states that this is a factor influencing the abundance of borers, and gives certain figures for the 1921–1922 crops to support his contention that plant-caness are invariably less attacked than are ratoons, the degree of infestation increasing annually with the age of the field. With the data available to the present writer the converse was more frequently found to hold good, third ratoons and "old canes" being more often than not the least, while plants and first ratoons generally the most, attacked by *Diatraea*, which conforms to what has been recorded by Wolcott (22) in Porto Rico and by other observers elsewhere. The writer does not consider that the age of any field or group of fields has such a marked bearing on borer infestation under British Guiana conditions as the variety of cane grown.

6. *Variety of cane.*—There is a decided relation between the variety of cane and its final infestation by *Diatraea* in British Guiana, as well as in other countries, e.g., Porto Rico, where Wolcott studied this aspect (21). In the Berbice cane-fields the standard D.625 occupies about 85 per cent. of the entire cultivation, whilst about 12 per cent. is D.625 mixed with the Barbados seedlings B.H.10 (12) and Ba. 6032. D. 145 is a cane that attracted attention a few years ago, and there still remains a small acreage under this variety, whilst other canes that are occasionally found in the fields are Bourbon, White Transparent (the Crystalina of Cuba and Porto Rico), Black Java (probably the same as Louisiana Purple, a dark sport of Crystalina), and a promising variety that caught the writer's attention through its apparent immunity to root-disease (*Marasmius*), and which was identified through the kindness of Sir John Harrison as Java 247 (G.Z. 247 B). New seedlings were received periodically from the Experiment Station of the British Guiana Sugar Planters' Association, and of those tested by the writer in 1923–1924, D. 707 appeared the most promising.

Unfortunately very few accurate figures are available of the comparative infestation by *Diatraea* of these varieties of cane, but such as follow may prove of interest :—

Comparison of D.625 and D.145 (first ratoons, cut April 1923).

Variety.	Final infestation.	
	Stalks.	Joints.
	Per cent.	Per cent.
D.625 ...	60.0	7.3
D.145 ...	94.0	12.4

Comparison of D.625, D.320, and D.747 (plants, cut May 1923).

Variety.	Final infestation.	
	Stalks.	Joints.
	Per cent.	Per cent.
D.625 ...	82.0	9.1
D.320 ...	93.0	11.4
D.747 ...	93.0	12.3

The writer's interest in this important aspect of the problem was stimulated during his recent visit to Porto Rico in 1924, and it is to be regretted that more data are not available. However, it was found that wherever D. 625 grew in proximity to B.H. 10 (12) and Ba. 6032, the Barbados hybrid was generally far less attacked than the standard cane, whilst Ba. 6032 was more heavily attacked than either B.H. 10 (12) or D. 625. Certain fields of seven-months'-old ratoons of D. 625 and B. 247, mixed with White Transparent, were examined, and the two latter varieties were found about 25 per cent. less attacked by *Diatraea* than the former. The relatively new D. 707 was decidedly less attacked than D. 625 when the two varieties were compared as plants of 8 months' growth in August 1924.

7. *Meteorological conditions.*—Accurate observations having been made over the last three years, it was found that the temperature and relative humidity varied so little that the question of their having any effect upon the incidence of moth borers remains debatable. Regarding rainfall, in general less borers were found at the beginning of the wet season than at its close and at the commencement of a long drought, when maximum abundance could nearly always be found in any locality. In explanation of this, the writer suggests that the minute egg-parasites reach their maximum efficiency towards the close of dry weather, and are temporarily wiped-out during periods of heavy rainfall.

Natural Enemies of *Diatraea* in British Guiana.

In no other country is *Diatraea* so heavily attacked by such a variety of enemies, both parasitic and predacious, as in British Guiana, and it is felt that the Colony is especially desirable as a source for introducing parasites to other countries where borers of the same genus occur as pests of sugar-cane. Vertebrate enemies such as birds* and lizards probably exert a small measure of control, but by far the greatest natural influences in checking the abundance of borers are the parasitic and predacious

* Two adult *D. saccharalis* were found in the stomach of a night-jar, *Nyctidromus albicollis* (det. by Mr. C. G. Young).

insects, a list of which, based on records in literature and the writer's own observations, is as follows :—

Parasites.

A. Of the eggs.

CHALCIDOIDEA.

1. *Trichogramma minutum*, Riley.
2. *Prophanurus alecto*, Crawford.—referred to as *Telenomus* sp. in early papers.

B. Of the larvae.

BRACONIDAE.

3. *Ipobracon grenadensis*, Ashm.—probably the *Ipbiaulax medianus*, Cam., of all other writers on *Diatraea* in British Guiana.
4. *Ipobracon puberulus*, Szep.—now recorded for what is believed to be the first time as parasitic on *Diatraea* in British Guiana.
5. *Ipobracon saccharalis*, Turn.—recorded by Turner (17).
- 6, 7, 8, 9. *Ipobracon* spp.—four species not yet determined.
10. *Microdus diatraeae*, Turn.
11. *Microdus parvifasciatus*, Cam.—referred to as *Cremnops parvifasciatus*, Cam., by Moore, Bodkin, and Cleare.
12. *Microdus* sp.—not yet determined.

ICHNEUMONIDAE.

13. *Mesostenoides* sp.—recorded by Moore, Bodkin & Cleare.

TACHINIDAE.

14. A Dexiine fly determined by the Imperial Bureau of Entomology as "*Stomatodexia* sp. very near to *S. diadema*, Wied." Specimens of this insect were sent to Mr. G. N. Wolcott in Porto Rico, who had them named by Mr. C. H. T. Townsend as *Leskiopalpus flavipennis*, Wied.

C. Of the pupae.

CHALCIDIDAE.

15. *Heptasmicra curvilincata*, Cam.

Predators.

1. An ant, *Ectatomma quadridens*, F.—recorded by Crawley (7).
2. Larvae of Carabid beetles of the genus *Scarites*.
3. Larvae of an Elaterid beetle, probably *Monocrepidius* sp.
4. Larvae and adults of the Histerid beetle, *Lioderma quadridentatum*.
5. Larvae of a Stratiomyid fly—recorded by Moore (13).
6. Attid and other spiders—recorded by Moore (13).

Vegetable Parasite.

A fungus, *Cordyceps (Isaria) barberi*.

Discussion on the Parasites.

There can be no doubt that the two egg-parasites exert the greatest influence in the biological control of *Diatraea* in British Guiana. *Trichogramma minutum* occurs in the fields all the year round, and at certain seasons, notably during prolonged dry weather, the parasitism of *Diatraea* eggs may be as high as 75 per cent., the average parasitism at all times being probably in the neighbourhood of 40 per cent. *Prophanurus alecto* was found quite commonly in the spring of 1923, emerging from egg-clusters brought in from the field. In general, however, it is much scarcer than *Trichogramma*, probably not more than 1 per cent. of all egg-clusters being parasitised by this species.

On the Berbice sugar estates no less than eight species of BRACONIDAE were found attacking borers in cane-stalks, and it is conceivable that in other parts of the Colony many other Braconids may occur as larval parasites upon *Diatraea*. For the study of parasites issuing from borers collected in dead-hearts the writer devised a special insectary, whereby advantage is taken of the phototropism of the wasps, the building being a modification upon a large scale of the well-known method of inserting a glass tube into a darkened box to trap small Hymenoptera. The following detailed description of the apparatus as used on the plantation is taken from one of the writer's reports to his employers :—

"A wooden building, 12 ft. by 8 ft. by 10 ft., with sloping corrugated-iron roof, is supported upon masonry pillars which rest in concrete cups containing an ant repellent (solignum or tar). The building has a few special features which allow of the capture of Braconid wasps, yet preventing the escape of moth-borers. There are two doors, the outer being solid and opaque, the inner on heavy springs being merely a frame covered with copper mosquito-mesh, allowing of ventilation and light when needed. There are two side windows, 2 ft. 2 in. square, also protected with wire mesh, and provided with adjustable roller-blinds of black Italian cloth on the outside, with 'lean-to's' to prevent the ingress of rain-water. At that end of the building which faces the morning sun is an opening, 1 ft. square, situated 6 ft. above the floor level; this opening is capable of being closed by means of a sliding shutter running in grooves on the outside of the building, but when opened allows of the insertion of a light frame cage, 2 ft. long, its ends very slightly smaller than the orifice in the wall of the insectary. One end of the cage (the other end is covered with mesh) can be pushed into the opening in the building, and is also grooved, and provided with its own sliding shutter, so that when pushed home it can be opened or closed independently. The interior of the building contains, besides the usual cages for the oviposition of captured or bred moths, a large cheese-cloth cage, 10 ft. by 4 ft. by 5 ft., in which are a number of shallow boxes to hold the cane-shoots brought in daily by the borer-gang (see 'Control') and from which the parasites emerge. Large numbers of *Diatraea* larvae leave the shoots and crawl about the inside of the insectary, pupating on the walls, etc., but the resulting moths will oviposit upon a number of cane leaves put into jars of water overnight, the eggs as they are obtained being used for rearing *Trichogramma*.

"When the outer door is closed, the blinds lowered, and the cage inserted with its shutter open, the interior of the building is in darkness until the shutter over the orifice in the wall is open, when the only source of illumination is through the cage, and it has been demonstrated that the Braconids fly to the cage within a few minutes after emergence. When the day's catch is complete, the end of the cage is closed by means of its shutter, and with its imprisoned contents is taken to the fields, where the parasites are to be released. The insectary is closed until further use by means of its independent shutter."

On an average from twelve to fifteen wasps, which would otherwise have been destroyed, can be trapped daily and released into the cultivation. From observations made over a period of over twelve months it was found that *Ipobracon grenadensis* and *Microdus diatraeae* were by far the commonest parasites, and this was confirmed by field observations made during the entire period of the writer's studies. On an average 2 per cent. of all dead-hearts will be found to contain one or the other of these wasps in either the larval stage, attached to the body of its paralysed host, or in the form of a cocoon. The life-cycle of each of these parasites occupies about 17 days, 13 or 14 days being spent in the cocoon, which is more or less cylindrical with blunt ends, varying greatly in size, but averaging three-quarters of an inch in length, that of *I. grenadensis* being the larger; the cocoon of this species appears rough and coarse in colour and varies from light brown to pale reddish buff, whilst that of *M. diatraeae* is silken in texture and is generally glistening white. The adults of both

species can always be observed at work in the cane-fields, and at certain seasons, notably at the beginning of the rains, are often excessively abundant, feeding at the flowering spikes of *Paspalum* spp. and flying around bushes of the genus *Cordia*, the "black sage" (*C. aubletii*) being most favoured.

Next in relative importance as a larval parasite of *Diatraea* is *Ipobracon puberulus*, which was found quite commonly in one restricted locality, where it seems to take the place of *I. grenadensis*; its activities appear to be confined to a belt of cane occupying about fifty or sixty acres, for the writer has not met with it elsewhere, and specimens were secured in the insectary only when dead-hearts were present from this locality. It may be of interest to record here that on the occasion of a visit by Dr. F. X. Williams, one of the entomologists of the Hawaiian Sugar Planters' Association, who came to British Guiana in the autumn of 1923 searching for beneficial insects to export to Hawaii, an authentic case of parasitism of the weevil stalk borer (*Metamasius hemipterus*) by *Ipobracon puberulus* was found by that gentleman in company with the writer; it is believed that this is the first case yet recorded of parasitism of *Metamasius* by a Braconid. Experiments failed to produce parasitism of the weevil grubs by this wasp under artificial conditions, and no further instances of such parasitism were met with, although many hundreds of weevil larvae have been examined from time to time.

Four other species of *Ipobracon* and one other of *Microdus*, which were sent to the Imperial Bureau of Entomology and reported as being "new to British Museum" (and possibly new to science), were met with from time to time, but their total value as controlling agents of *Diatraea* must be negligible, at least in the West Berbice cane-fields.

The wasp *Heptasmicra curvilineata* emerged from dead-hearts in the insectary on four occasions only, but these conspicuous yellow-and-black Chalcids are sometimes quite common in the field; in one instance a wasp of this species emerged from a pupa of *Diatraea* kept in captivity, and as wasps of this type are known to attack Lepidopterous pupae, it is concluded that *H. curvilineata* is parasitic upon that stage of moth borer. Trials were made with *Diatraea* larvae and pupae in captivity, but no cases of parasitism could be obtained.

The Tachinid (Dexiine) fly parasite appears to be scarce in Berbice, but on estates in Demerara is reported as occurring more or less in abundance. The puparia were, however, occasionally met with in dead-hearts, and the fly itself is sometimes seen resting upon cane leaves in the fields.

At times, more especially in the middle of rainy seasons, as many as two per cent. of all borers found are seen to be mummified through attack by the parasitic fungus, *Cordyceps barberi*, which must be considered as greatly assisting the control of the pest. In dry weather borers are seldom seen to have been killed in this way.

It is regrettable that in a country where there exist such numerous parasitic enemies of the worst pests of the staple industry, a custom, viz., burning cane-fields, is in vogue which so greatly reduces their efficiency. Several planters assure me that in the "good old days," when the Bourbon cane predominated and cane-fields were cut without being burned, the moth borers were very much less severe than they have been during the last two or three decades. In Cuba and in Porto Rico *Diatraea saccharalis* is attacked by but one parasite of any importance, the Tachinid *Euzenilliopsis diatraeae*, Towns., yet the pest never reaches the status that it does in British Guiana; it is significant that cane-fields are seldom if ever burnt in those countries.

The Control of *Diatraea* in British Guiana.

It can well be understood that under the conditions in which sugar-cane is grown in British Guiana, the borers have opportunities to increase which do not occur elsewhere, and as this state of affairs has been going on for many years, the pest has

in consequence reached a status now unique in the sugar-cane world. Planters, however, are not blind to the havoc wrought in the plantations and for many years have employed gangs of labourers, mostly the children of East Indian immigrants, in charge of a "driver," who systematically go through the young cane-fields cutting out dead-hearts and removing the borers, for which they are paid at rates varying from 6 cents (3d.) to 24 cents (1s.) per hundred, according to the abundance of the insects. The writer found that better results were obtained from the workers when the price was standardised to 12 cents (6d.) per hundred. The children have been trained to avoid damaging borers which are parasitised by the Braconid wasps, these being left in the fields. Fair numbers of these parasites, however, in their earlier stages are to be found in dead-hearts brought in by the gang, and these are enabled to complete their development and are returned to the fields by means of the special insectary already described.

The number of borers brought in daily by the gang (which averages about 17 persons) is around three thousand, but in heavy outbreaks as many as twelve or fifteen thousand *Diatraea* larvae and pupae may be collected each day.

Table V. shows the numbers of borers collected monthly over the two estates during 1922 and 1923 :—

TABLE V.

Month.	Estate " A. "		Estate " B "	
	1922.	1923.	1922.	1923.
January	—	163,840	—	203,900
February	132,430	311,020	178,980	169,350
March	109,310	225,070	133,120	284,200
April	38,350	124,050	112,750	92,400
May	42,135	150,670	112,968	231,150
June	78,090	137,110	108,060	111,340
July	45,386	131,810	70,440	112,180
August	23,820	99,900	8,180	48,530
September	13,420	—	5,600	9,200
October	4,605	—	8,600	1,390
November	20,156	29,614	14,500	8,870
December	86,931	19,159	115,960	8,690
Totals	594,633	1,392,243	869,158	1,241,200

The number of borers obtained depends upon the extent of infestation and the amount of labour available, whilst monthly totals vary with climatic conditions and the acreage available for the gangs' operations, as dead-hearts can be cut only from fields of less than four months' growth.

When the number of dead-hearts was excessively high, *i.e.*, 30 per cent. or more of the total number of shoots, it was found cheaper and more effective to cut out and destroy all the spring and allow the field to ratoon again under comparatively borer-free conditions.

Apart from the employment of borer gangs, no other forms of artificial control of *Diatraea* are practised in British Guiana ; the method of the insect's attack precludes the possibility of applying any form of spray or dust to the crop, and the use of trap lanterns is hardly conceivable where such heavy infestations occur over large areas of sugar-cane.

The writer believes that the eventual control of *Diatraea* in British Guiana will follow a thorough study and application of the knowledge of its natural enemies within the Colony, and the importation of suitable parasites from abroad to assist those

already at work. Special insectaries for breeding local and imported parasites will, in time, be erected and maintained for every thousand acres or so under cane, if any reduction in the number of the pest is to be obtained.

The regular borer-gangs, in addition to collecting the larvae and pupae of *Diatraea*, are expert at finding the egg-clusters upon the leaves of canes; at times as many as ten or twelve thousand such clusters are brought in daily by the gang. Those egg-clusters which are parasitised in the field by either *Trichogramma* or *Prophanurus* are recognisable by their black colour, and are not collected by the gang, but a large proportion of the clusters collected are also parasitised, not yet having changed their colour; these are kept in the laboratory in tins resting in an ant-repellent, and retained for a length of time sufficient to enable any of them that are parasitised to turn black, when the latter are sorted out and returned to the fields, three hundred of such per day not being unusual; the remaining unparasitised eggs are destroyed, any borers hatching from them being confined to the receptacles until they can be killed. The details of this system have been described by Moore (12, 1917) and Cleare (6). To the latter entomologist belongs the credit for being the first to breed *Trichogramma* upon anything like a commercial scale for release in the fields, but the writer feels that a description of the method used should come from the pen of Mr. Cleare himself. However, under the system adopted, which was continued by the writer with a few minor improvements, the following numbers of egg-clusters were raised and parasitised in the laboratories :—

TABLE V.

Period.	Estate "A."	Estate "B."
Feb.-Dec. 1922 ...	21,673	44,770
Jan.-Sept. 1923 ...	30,266	33,565

The average number of eggs per cluster is 35, and 2.5 may be considered the average number of parasites per egg; on this basis no less than 4,570,630 *Trichogramma* were released on Estate "A," and 6,783,480 on Estate "B" during the period February 1922 to September 1923. Whilst a certain amount of good must follow such useful work as this, the parasites should be bred in much larger quantities to produce any material effect, as the number released in any field represents a minute proportion of those already in the field in a state of nature. Could the output be multiplied by a hundred probably some reduction in the numbers of borers might follow as a result, but the expenses of buildings, skilled labour, etc., attached to such breeding work could hardly be borne by the average sugar estate in British Guiana at present.

The Introduction of Parasites from Abroad.

Early in 1923 the writer suggested that it might be worth trying to import into British Guiana the Tachinid *Euzenilliopsis diatraeae*, Towns., which exerts such a marked influence in the control of *Diatraea saccharalis* in the islands of the Greater Antilles, and which has occupied the attentions of sugar-cane entomologists in Louisiana and Mexico during recent years. On 23rd June a memorandum was submitted by the writer to the Chairman and Members of the British Guiana Sugar-Planters' Association, suggesting that in view of the partial success which has followed the introduction of this fly (erroneously referred to as *Cryptomeigenia* in the memorandum) to the North American continent, probably some measure of success might follow its introduction to the British Guiana canefields, and urging the Association to make the experiment. The Chairman (Sir John

Harrison) expressed his agreement that a trial be made, such, however, to be carried out by the Government Entomologist (Mr. Cleare) co-operating with the writer, any flies that might be obtained to be tried out in quarantine at the Government Experiment Stations. Considerable discussion of the matter followed, in which those antagonistic to the scheme (who were legion) expressed fears for the safety of the Colony's sugar industry in the event of such an introduction coming to pass, quoting for comparison the mongoose disaster of Trinidad. It was also suggested that success would be improbable owing to the existence in British Guiana of certain alleged hyperparasites upon native Tachinidae. Much correspondence followed during the next six months, but in April 1924 the writer was authorised to proceed to Porto Rico and, if necessary, to Cuba in search of the desired insects, all expenses being borne by the enterprising company for whom he was engaged. Sixty copies of the writer's detailed report upon his trip to Porto Rico in the summer of 1924 were printed for private distribution (4), but a brief résumé of the work and its results, some of which post-date the appearance of the report, may not be out of place.

Sailing from Demerara on the 26th April, the writer arrived at San Juan, the capital of Porto Rico, on 5th May 1924. Two months were spent upon the Island, and during that time visits were made to most of the districts where sugar-cane is grown, largely owing to courtesies extended to the writer by the Director and Staff of the Insular Experiment Station of Porto Rico.

In order to obtain some idea of the behaviour of *Diatraea* parasites on the journey to and from Demerara, the writer took with him to Porto Rico about two hundred cocoons and larvae of the British Guiana Braconids, these being kept in cold storage during the eight-day voyage via Trinidad and Venezuela. Upon arrival in Porto Rico this material was handed over to Mr. Wolcott, then entomologist of the Insular Experiment Station. Adults commenced to emerge immediately the material was restored to normal temperature, and on 12th May two males and twelve females were released upon one of the plantations of the Central Aguirre Sugar Company, situated on the south coast of the island, which is a comparatively dry region, canes being grown under irrigation. On 19th May a second release was made of six males and seven females at Rio Piedras on the north coast. Both *Ipobracon grenadensis* and *Microdus diatraeae* were represented in this material, and that the latter has become established in Porto Rico is shown by recoveries made on the south coast during February and March 1925, three cocoons (adults emerged from two of them) and two parasitised borers being found in dead-hearts in a field four miles from the original point of release.

Regarding the Tachinid fly, which was the object of the writer's visit to Porto Rico, specimens were found wherever the borers occurred, and in some localities, e.g., at Bayamón on the north coast, five miles west of San Juan, 20 per cent. of the borers in parts of some fields were found to be attacked by *Euzenilliopsis*, the parasite being found generally in the form of puparia in the tunnels made by *Diatraea* in cane-stalks; a fair number of the parasites were found in the larval state within the body of parasitised borers, through the integument of which they are readily seen. Owing to the limited means of transportation between Porto Rico and Demerara, it was found feasible to make only two shipments of the flies, viz., 88 puparia and 8 larvae on 5th June, and 149 puparia on 3rd July; these consignments arrived at the estate laboratory on 15th June and 13th July respectively. All the insects were kept at a temperature of 38°-40° F. whilst in transit. From the first consignment 35 flies emerged during the four weeks following their arrival, and from the second lot 54 flies emerged during the 10 days subsequent to their arrival; the percentage of emerging flies being 32.2 of the total number of larvae and puparia shipped.

The flies obtained from the first consignment were released in a large cage constructed over growing canes which had been artificially infested with *Diatraea*

larvae of all sizes, but no cases of parasitism by the imported fly were recorded, so that it was considered advisable to release the whole of the second lot directly into a borer-infested cane-field.

In November 1924, the writer saw a fly very much like *Euzenilliopsis diatraeae* resting upon weeds in a field not far from where the imported insects had been released, but as the fly was not captured it cannot be said for certain that it was of that species. During December an examination was carried out of dead-hearts collected in the field where the Tachinids had been released five and a-half months previously and two puparia were found; unfortunately the flies had emerged from both of them, but as no similar puparia were likely to be found under such circumstances it was concluded that they belonged to the introduced species. That the experiment was successful as an introduction was proven by the finding upon the penultimate day of the writer's stay in Berbice of one puparium from which a small male *E. diatraeae* emerged during the writer's return to Porto Rico in January 1925.

It is to be hoped that every opportunity will be given to aid in the successful dispersal of the flies in British Guiana, and this could be materially assisted by leaving small areas unburned in the neighbourhood of the July releases.

The writer has been residing in Porto Rico since the middle of January, most of this time being spent upon the extensive properties of the Central Aguirre Sugar Company, and has had opportunities for the further study of *Euzenilliopsis diatraeae*. Whilst in June 1924 the fly was decidedly scarce on the south coast, seven months later parasitism of borers was as high as 23 per cent. in many fields, the average of such parasitism being around 12 per cent. of all borers found during February and March. If there is, as is most likely, a corresponding increase in parasitism upon the north coast, the best time for collecting flies for shipment from Porto Rico would seem to be the earlier months of the year. It is considered that the sugar-cane growers of British Guiana would not be ill-advised to have an entomologist again visit the "Isle of Enchantment", at a season when the parasites are more abundant than the writer found them in the summer of 1924, and continue shipping these beneficial insects to where they are needed, and, indeed, planters in the island of Barbados, where *Diatraea* takes heavy toll of the sugar-cane crop, might well follow suit, for in this direction it is felt the best and most speedy results will follow.

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CONTRIBUTION TOWARDS OUR KNOWLEDGE OF THE ALEYRODIDAE OF CEYLON.

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In this paper the species of ALEYRODIDAE occurring in Ceylon are listed, and the descriptions of two genera and nineteen species new to science are included.

The writer's thanks are due to Mr. E. E. Green, who kindly supplied him with his collection which contained twenty-nine species of Aleyrodids, and to Mr. F. Laing who, by his willing assistance, his helpful suggestions and his keen interest, made the publication of this paper possible.

Genus **Aleurodicus**, Douglas.

Aleurodicus, Douglas, Ent. Mo. Mag. (2) 3, 1892, p. 32.

Aleurodicus holmesii, Maskell.

Aleyrodes holmesii, Maskell, Trans. N.Z. Inst. xxviii, 1895, p. 435.

Aleurodicus holmesii, Maskell, Ckll., Fla. Agr. Exp. Stn. Bull. 67, 1903, p. 644.

This insect was originally recorded from Fiji on *Psidium* sp. and later by Woglum from the Botanic Garden, Buitenzorg, Java, on a plant of the family Sapindaceae. Green's specimens were collected on an unknown plant at Kandy, i.1910.

Short, brittle, glassy wax rods occur with the pupa-cases on the upper surface of the leaf.

Aleurodicus antidesmae, sp. n. (fig. 1).

Pupa dirty white in colour, raised on a vertical rim composed of white wax deflexed from possibly small wax pores on the margin of the case and surrounded by rather short, brittle, glassy wax rods produced by the compound wax-pores. Length 1.29

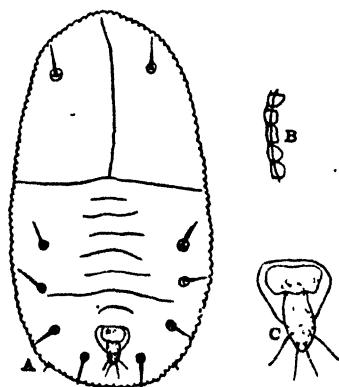


Fig. 1. *Aleurodicus antidesmae*, sp. n. : A, pupa ; B, margin of pupa-case ; C, vasisform orifice.

mm., breadth 0.65 mm. ; sub-ovate in shape. Margin dentate, with about 62 pairs of teeth and a pair of small spines latero-posteriorly. Wax-pores at the margin are not evident. Mid-thoracic and transverse sutures distinct. Abdominal segments

differentiated. Subdorsal area with five equal pairs of large compound pores—one anteriorly on the cephalo-thorax and four pairs on the abdomen; each pore armed with a strong spine. Vasiform orifice subcordate; operculum twice as long as broad and about half-filling the orifice; posterior margin sinuate, with a pore of short setae; lingula large, setose, exserted, spatulate, narrowing at the base, with two pairs of spines at distal end.

Pundaluoya, on *Antidesma bunius* (E. E. Green).

This species has been described from only one specimen which was situated near the mid-rib on the lower surface of the leaf.

Genus **Dialeurodes**, Cockerell.

Dialeurodes, Ckll., Proc. Acad. Nat. Sci. Phil. 1902, p. 280; Quaintance & Baker, Bur. Ent. U.S. Dept. Agr., Tech. Ser. Bull. 27, pt. 2, 1914, p. 97.

Dialeurodes radiipunctata, Quaintance & Baker.

D. (Dialeurodes) radiipunctata, Q. & B., Proc. U.S. Nat. Mus. i, 1917, p. 418.

This species was described from material sent by Rutherford and collected on *Memecylon* sp., Peradeniya, 10.xi.1913.

Dialeurodes (Rabdostigma) radiilinealis, Q. & B.

Dialeurodes radiilinealis, Q. & B., Proc. U.S. Nat. Mus. li, p. 436.

The pits on the lower surface of the leaves are shallow and make little impression on the upper surface. *D. (Rabdostigma) loranthe* causes much deeper pits, producing a galled effect on the upper surface of the leaf. It should be mentioned that the dorsum of all the species which I have examined shows a marked tessellation (fig. 2) and

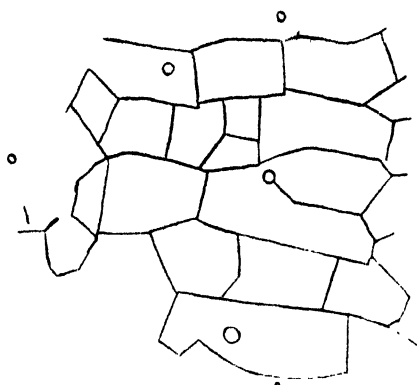


Fig. 2. *Dialeurodes (Rabdostigma) radiilinealis*, Q. & B., tessellation and bases of spines on dorsum of pupa-case.

carries very minute spines. Dr. C. D. Baker informed me that of his material only the parasitised individuals have a tessellated dorsum. I refrain from making a new species until I have examined more material. This Aleyrodid was originally described from material collected by Marlatt on mistletoe at Nuwara Eliya, 26.i.1902. Green's specimens were collected on the same plant at Peradeniya, vi.1910.

Dialeurodes (Rabdostigma) loranthe, sp. n. (fig. 3).

Pupa yellowish, subcircular, no secretion of wax evident, situated on lower surface of leaf, generally sunk in large, deep depressions; length, 1.23 mm.; breadth, 1.05 mm. Margin crenulated; sutures running in from margin conspicuous, more

distinct than in *D. radiilinealis* and wavy for about 0.068 mm. ; in subdorsal area these give place to polygonal markings which decrease in size towards mid-dorsal line. Derm with a tessellated appearance. Transverse suture bending sharply forward and then curving inwards to meet the corresponding half of the other side mid-dorsally ; two other transverse sutures present dividing this demarcated area on cephalo-thorax into three transverse areas—not so marked as in *D. radiilinealis*.

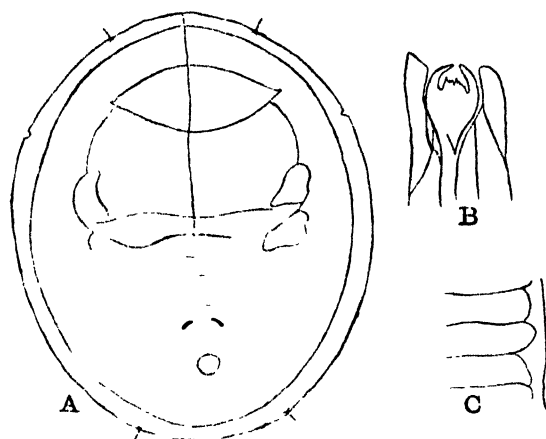


Fig. 3. *Dialeurodes (Rabdostigma) loranthi*, sp. n. : A, pupa ; B, tracheal pore ; C, margin of pupa-case.

Abdominal segments slightly differentiated. Tracheal pores situated at a slight distance from margin and encircled by a ring of teeth, the exact number of which it is difficult to distinguish. No caudal pore present. On anterior and posterior lateral margins there is a pair of small spines. Vasiform orifice subcordate ; operculum similar and obscuring the lingua.

Hewaheta, viii.1910, on *Loranthus* (E. E. Green).

This species causes deep pitting of the lower surface of the leaf.

***Dialeurodes (Rhachisphora) rutherfordi*, Quaintance & Baker.**

Dialeurodes rutherfordi, Q. & B., Proc. U.S. Nat. Mus., li, p. 432.

Peradeniya, 1913, on leaves of *Loranthus* (Rutherford).

***Dialeurodes (Rhachisphora) trilobitoides*, Quaintance & Baker.**

Dialeurodes trilobitoides, Q. & B., Proc. U.S. Nat. Mus., li, p. 433.

Peradeniya, on an unknown plant (*Woglum*), on *Harpullia* sp. and on *Eugenia operculata* in 1913 (Rutherford).

This would appear to be one of the most common and readily seen Aleyrodids in Ceylon, since in Green's collection of some 43 packets it occurred nine times. The pupa is made conspicuous by having white wax on the mid-dorsal ridge and on the ridges running towards the margin. Green's collection does not to any large extent augment our knowledge of the host-plants. He collected this insect on an unknown plant at Neboda, ii.1895 ; at Tangalla, vi.1894 ; at Batticaloa, v.1906 ; at Sigiriya, viii.1909 ; at Haragama, ii.1908 ; at Trincomali, ix.1910 ; at an unrecorded place, vi.1906 ; on *Memecylon* sp. at Kesbewa, iv.1903 ; and at Maha Illupalawa, North Coast Province, ix.1905.

***Dialeurodes (Rhachisphora) capitatis*, sp. n. (fig. 4).**

Pupa on leaf whitish and made conspicuous by the wax secretion, which is exuded in the nature of columnar glassy rods from the dorsal papillae. Length, 1.48 mm.; breadth, 1.05 mm.; ovate, margin slightly and irregularly crenulate. Abdominal segments distinct, giving the appearance of a rhachis. Tracheal and caudal pores distinct, crenulations in these areas slightly more definite. With the exception of the pairs of setose spines on the latero-posterior and the posterior margins, there are about 12 pairs of submarginal, slightly vasiform spines extending

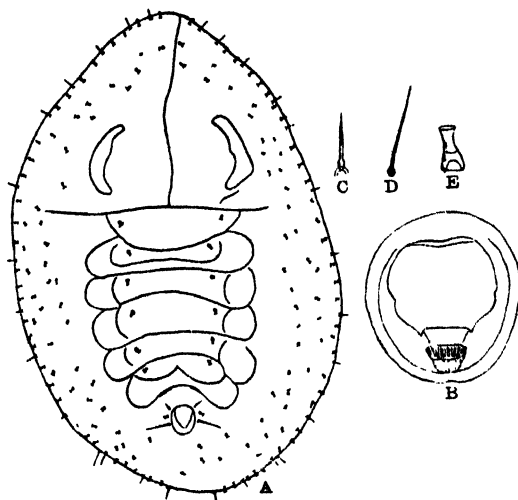


Fig. 4. *Dialeurodes (Rhachisphora) capitatis*; sp. n.: A, pupa; B, vasiform orifice; C, submarginal spine; D, marginal spine; E, apitate spine.

about half their length beyond the margin. A row of capitate spines arise just interior to the submarginal spines and do not for the most part extend beyond the margin. There are 4-5 rows of these capitate spines throughout the dorsum of the pupa-case; the rows nearest the dorsal area being the smallest. Each abdominal segment is armed with a pair of these large papillae. Vasiform orifice subcircular with a conspicuous notch at distal end; operculum about half filling the orifice, exposing the lingula, which is setose and would appear to be ringed with fine hairs.

Nuwara Eliya, iii.1911, on an undetermined plant (*E. E. Green*).

***Dialeurodes (Rhachisphora) setulosa*, sp. n. (fig. 5).**

Pupa on leaf stramineous or light brown, but of a deeper brown mid-dorsally, no waxy secretion visible; elliptical; length, 1.64 mm.; breadth, 1.17. Margin crenulate, sutures evident in submarginal area; eleven pairs of inconspicuous vasiform spines in submarginal area, the apices of which do not extend beyond the margin; a pair of longer spines on anterior lateral margin and on margin posterior to the vasiform orifice. Thoracic folds ending in circular pores armed with a sinus of teeth, a short distance in from the margin. Caudal fold with, on either side, a narrow band densely crowded with brownish polygonal areolations. (Termination of caudal fold cannot be discerned in slide.) Rhachis very prominent, brown in colour, mid-dorsal area crowded with small polygonal markings which gradually disappear laterally; transparent dorsally; abdominal segments distinct and bearing pores. In cephalo-thoracic region small pores and spatulate spines evident,

together with polygonal markings. Anterior end of rhachis cone-shaped. Subdorsal area covered with numerous scabrous spines, and folds from abdominal sutures distinct.

Haberane, on an unknown plant, viii.1909 (*E. E. Green*).

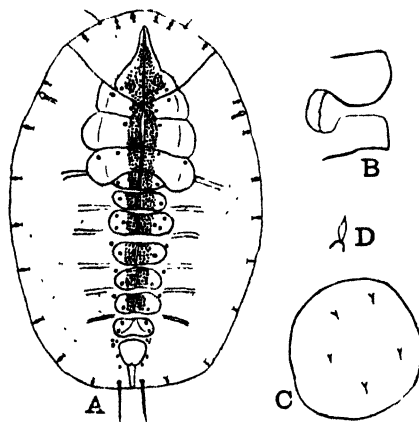


Fig. 5. *Dialeurodes (Rhachisphora) setulosa*, sp. n.: A, pupa; B, tracheal pore; C, part of dorsum showing setulose spines; D, vasiform submarginal spine.

***Dialeurodes (Dialeuropora) decempunctata*, Quaintance & Baker.**

Dialeurodes decempunctata, Q. & B., Proc. U.S. Nat. Mus., li., p. 434.

Peradeniya, on cinnamon, x.1910; and Lahore, India, on mulberry (*R. S. Woglum*).

Genus ***Aleuroplatus***, Quaintance & Baker.

Aleuroplatus, Q. & B., Bur. Ent. U.S. Dept. Agr., Tech. Ser. 27, pt. 2, 1914, p. 98.

***Aleuroplatus (Aleuroplatus) incisus*, Q. & B., Proc. U.S. Nat. Mus. li, p. 358.**

Peradeniya, on *Ostodes zeylanica*, x.1910 (*R. S. Woglum*); and on *Garcinia specta*, ix.1913 (*A. Rutherford*); at Harputalo, 5,000 ft., xii.1904, on an unidentified plant (*E. E. Green*).

***Aleuroplatus (Aleuroplatus) ficus-gibbosae*, sp. n. (fig. 6).**

Pupa situated on upper surface of leaf, dark brown to black, with no wax fringe; length 0.98 mm., breadth 0.70 mm.; ovate, margin dentate, seemingly double and depressed at the thoracic and caudal folds. Folds not evident, but teeth prominent, about 9 in number, middle ones largest. Subdorsal area with an irregular row of pores running right round the pupa-case, and in submarginal area another row, which is not so distinct; between these two rows, other rows of smaller pores are present; pairs of small spines situated on the latero-anterior and latero-posterior margins, another pair near the mid-thoracic suture (about mid-way between the anterior margin and transverse suture), another just in front of the vasiform orifice, and a third posteriorly near the margin. The transverse suture turns slightly forward anteriorly and is distinct. Abdominal segments distinct in mid-dorsal region; thickenings on

sutures evident. Vasiform orifice elevated, subcordate in shape and toothed on inner posterior and lateral margins ; operculum about half-filling the orifice and similar to it in shape.

Peradeniya, i.1905, on *Ficus gibbosa* (E. E. Green).

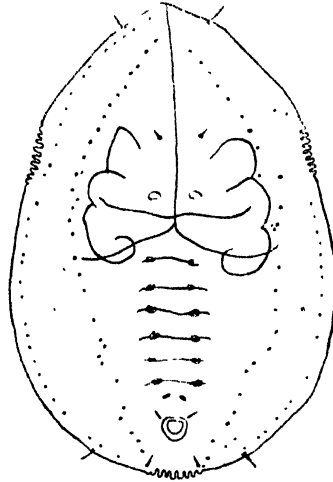


Fig. 6. *Aleuroplatus ficus-gibbosae*, sp. n.

***Aleuroplatus (Orchamus) premnae*, sp. n. (fig. 7).**

Pupae found on lower surface of leaf of host-plant. Colour varying from transparent to light brown, median line always yellow ; no wax fringe discernible ; length 0.94 mm., breadth 0.82 mm. Pupa-case subovate in shape, anterior margin slightly pointed. Median ridge prominent, especially in cephalothoracic region ; margin with a double row of teeth, the outer row simply dentate, the inner row slightly capitate (fig. 7, c). Teeth of thoracic and caudal folds not conspicuously larger than the marginal ones, the folds themselves not evident. Marginal rim differentiated. Conspicuous simple pores present and generally distributed throughout dorsum, except

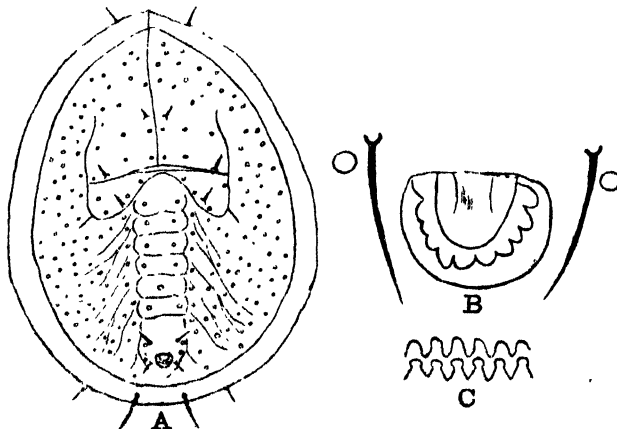


Fig. 7. *Aleuroplatus (Orchamus) premnae*, sp. n. : A, pupa ; B, vasiform orifice ; C, margin of pupa-case.

on marginal area. Suture separating submarginal and subdorsal areas absent. Rhachis present, but not strongly developed; transverse sutures faintly developed towards margin. Pores on abdominal segments. Vasiform orifice small, subcordate, with inner and lateral margins toothed; operculum half-filling orifice and of similar shape; lingula setulose. Anterior and posterior lateral margins each with one pair of spines, three pairs on anterior portion of case; vasiform orifice surrounded by three pairs of spines, a fronto-lateral, a lateral, and a posterior pair.

Peradeniya, on *Premna cordifolia* (E. E. Green).

This species is readily distinguished from other members of the same subgenus by the pore system.

Genus **Bemisia**, Quaintance & Baker.

Bemisia, Q. & B., Bur. Ent. U.S. Dept. Agr., Tech. Series 27, pt. 2, p. 99.

Bemisia emiliae, sp. n. (fig. 8).

Pupa transparent yellow; situated on lower surface of leaf; slight waxy fringe present; in some specimens there is a pair of rather large, yellowish patches in subdorsal area at about the fourth abdominal segment; subovate; length 0.98 mm., breadth 0.68 mm. Margin crenulate, depressed in cephalo-thoracic region; a pair of small spines on anterior margin. Transverse suture distinct and abdominal segments evident. Tracheal folds present and covered with minute circular markings. On cephalo-thorax three pairs of spines (two pairs represented by their bases in fig. 8); behind

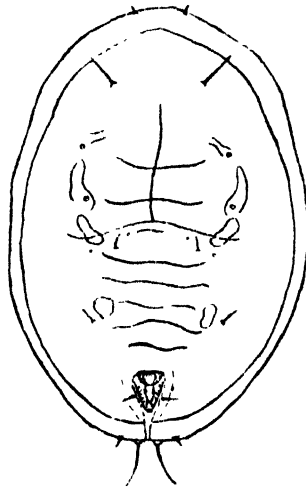


Fig. 8. *Bemisia emiliae*, sp. n.

transverse suture three pairs of minute spines, and in region of fifth abdominal segment another small pair; pores on dorsum not evident. Vasiform orifice typical of genus, triangular in shape; operculum subcordate, lingula exposed and armed with two spines; lateral margins of the orifice with conspicuous projections and mid-laterally a pair of spines; operculum and lingula setose. Caudal fold prominent; at its distal end a pair of prominent spines on tubercles and more laterally a pair of small setae.

Hakgala, on *Emilia sonchifolia*, v.1912 (E. E. Green).

This species is separated from *religiosa* by having a transparent waxy fringe and by its dorsal spines not being so conspicuous, and from *leakii* by having spines on the dorsum.

Genus **Aleyrodes**, Latreille (1795).

Aleyrodes hyperici, sp. n. (fig. 9).

Pupae rather inconspicuous on leaf, crowded together and of a light brown colour. Case elliptical in shape; length 0.94 mm., breadth 0.73 mm.; margin crenulate, more distinct posteriorly. Tracheal folds not discernible; cephalo-thoracic and transverse sutures distinct; abdominal sutures moderately prominent in mid-dorsal area. Vasiform orifice subcordate; operculum about half-filling the orifice; lingula exserted, setose and carrying a pair of spines at distal extremity. Pairs of small

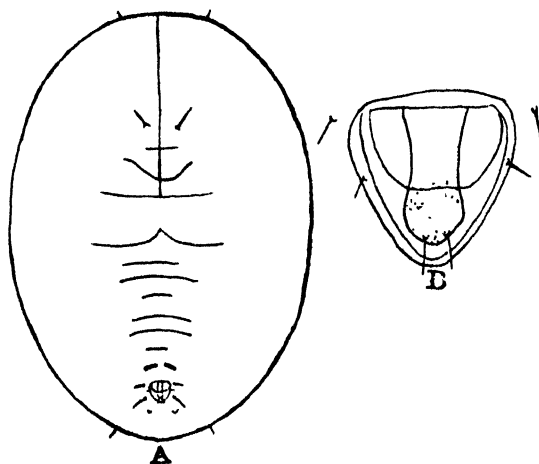


Fig. 9. *Aleyrodes hyperici*, sp. n.: A, pupa; B, vasiform orifice.

spines are situated on the anterior and posterior lateral margins, on cephalo-thoracic region near mid-dorsal line, near vasiform orifice at latero-anterior margin, on mid-lateral margin and a more prominent and more lateral pair behind these. In some specimens, posterior to the last pair of spines there is a pair of thickened chitinised plates or bases of spines.

Nuwara Eliya, on *Hypericum* sp. (E. E. Green).

Genus **Aleurocybotus**, Quaintance & Baker.

Aleurocybotus, Q. & B., Bur. Ent. U.S. Dept. Agr., Tech. Series 27, pt. 2, 1914, p. 101.

Aleurocybotus setiferus, Q. & B.

Aleurocybotus setiferus, Q. & B., Proc. U.S. Nat. Mus., li, 1917, p. 357.

This species was found in Java in 1907 on *Imperata* sp., and at Peradeniya, in 1913, on a grass. Green's specimens were collected at Peradeniya on *Imperata arundinacea*, iv.1907.

Genus **Aleurocanthus**, Quaintance & Baker.

Aleurocanthus, Q. & B., *op. cit.*, 1914, p. 102.

Aleurocanthus citripardus, Q. & B.

Aleurocanthus citripardus, Q. & B., *op. cit.*, 1914, p. 102.

This species was taken by R. S. Woglum at Peradeniya, Ceylon, on an unknown tree, x.1910, and also on *Citrus* in Java, i. and vii.1911.

***Aleurocanthus piperis*, Maskell.**

Aleurodes piperis, Mask., Ckll., Trans. New Zealand Inst., xxviii., 1896, p. 438.

This insect has been previously recorded from Ceylon on *Piper nigrum* (?). E. E. Green's specimens were collected on an unknown plant at Pundaluoya and on betel pepper (*Piper betle*) at Peradeniya, vii.1909.

***Aleurocanthus spiniferus*, Quaintance.**

Aleurodes spinifera, Q., Can. Ent. xxxv, 1903, p. 63.

This Aleyrodid was recorded on *Citrus* sp. and rose from Java from material collected by C. L. Marlatt, xii.1901. E. E. Green's specimens were obtained at Kandy, on rose leaves, v.1907.

***Aleurocanthus woglumi*, Ashby.**

Aleurocanthus woglumi, Ashby, Ann. Rept. Dept. Agr. Jamaica, 1914-15, p. 31 ; Q. & B., Jl. Agr. Res. vi., 1916, p. 463.

This insect is widely distributed, having been recorded from the Philippines, Bahamas, Jamaica, Ceylon and India, and is found generally on *Citrus* plants. Other recorded hosts in Ceylon are *Capparis roxburghi*, *Capparis pedunculatus*, *Salacia reticulata* and *Kurrimia zeylanica*. Green's collections show that this insect is fairly prevalent in Ceylon, as they were obtained on undetermined plants at Colombo and Pundaluoya, v.1909, and on a frond of a coconut palm (*Cocos nucifera*), at Haragama, v.1909. There are variations in the number of spines and in the size of the marginal teeth in these specimens as compared with the typical *A. woglumi* from Jamaica, but the general appearance of the pupa-case is so similar that to erect new species on such minor characters would not serve any useful purpose.

***Aleurocanthus obovalis*, sp. n. (fig. 10).**

Pupa obovate ; length 0.94 mm., breadth 0.70 mm. ; margin dentate, with the teeth regular and rounded ; a space of 0.1 mm. is occupied by 8-9 teeth. On the dorsum there is an irregular ring of eleven pairs of conspicuous spines, four pairs on the cephalo-thorax and seven pairs on the abdomen, the most anterior pair being

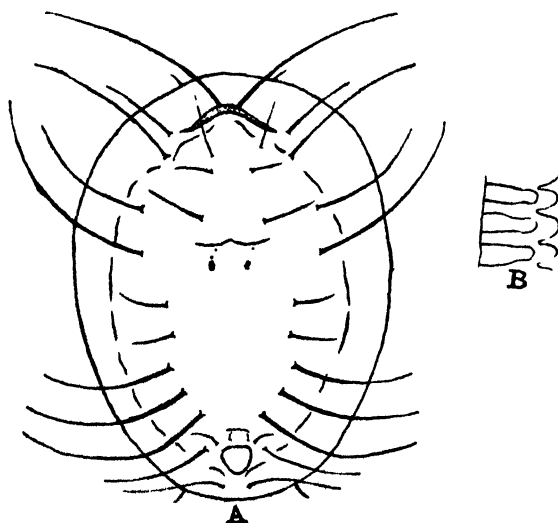


Fig. 10. *Aleurocanthus obovalis*, sp. n. : A, pupa ; B, margin of pupa-case.

the longest, whilst the sixth and seventh pairs are the shortest and arise nearest to the mid-dorsal line ; in the mid-dorsal area of the cephalo-thorax there are three pairs of spines, the most anterior pair being very fine ; posterior to the transverse suture there are probably three short spines, only the bases of which are discernible ; anteriorly, latero-anteriorly and latero-posteriorly of the vasiform orifice arise other pairs of spines, the foremost of which is very short, whilst the last is very fine and long ; on the anterior and posterior margins of the pupa-case a pair of spines is evident. An interrupted chitinised fold runs round the pupa-case in the submarginal area. Vasiform orifice subcordate, and the operculum similar in shape.

Pundaluoya, on a leaf of bamboo (*E. E. Green*).

This species may be distinguished from its near allies by its shape and by its having one row of conspicuous spines in the subdorsal area of the abdomen.

***Aleurocanthus niger*, sp. n. (fig. 11).**

Pupa black, with a slight white marginal wax fringe, subcircular with an octahedral appearance ; length 1.87 mm., breadth 1.66 mm. Double margins present, exterior dentate with 6-7 teeth to 0.1 mm., interior about 0.05 mm. from outer margin and consisting of widely separated teeth which are variously rounded. Interior to the second margin, there is a ring of spines, the bases of which give the pupa-case the appearance of having a suture between the submarginal and subdorsal areas, the spines being arranged in regular formation. The details of the spines are difficult to follow, but there would appear to be nine pairs of long spines (three pairs on the

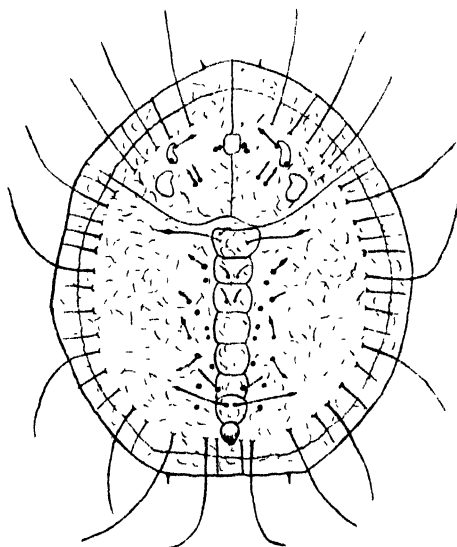


Fig. 11. *Aleurocanthus niger*, sp. n.

cephalo-thorax and six on the abdomen) and 13 pairs of short spines, 11 pairs of which are situated on the abdomen ; in the spaces between the spines are very small pores (spines). All these spines appear to have their apices slightly swollen, giving them a slightly vasiform appearance. The details of all the spines in the mid-dorsal area cannot be distinguished, but all apparently are hastate. The whole dorsum has a distinctly rugose appearance. On the anterior and posterior margins are pairs of small setae. The transverse suture, which extends to the margin, is distinct, so also are the sutures between the abdominal segments. Vasiform orifice subcordate, and with conspicuous projections on its inner and lateral margins.

Pundaluoya, on bamboo (*E. E. Green*).

***Aleurocanthus nigricans*, sp. n. (fig. 12).**

Pupa-case on leaf shiny black, with a narrow waxy marginal secretion ; no dorsal secretion evident ; sub-elliptical ; length 1.57 mm., breadth 1.35 mm. Under the microscope the colour appears as dark brown, especially on the cephalo-thorax, where the characters are difficult to make out. Margin with a double row of teeth ; outer row with 6-7 teeth to 0.1 mm., inner row situated about 0.062 mm. from the margin. Transverse suture distinct to margin. Median ridge evident, especially in abdominal region. Surface of case rugose. In the submarginal area a ring of 68 spines present, which are frequently in groups of threes with a long spine separating

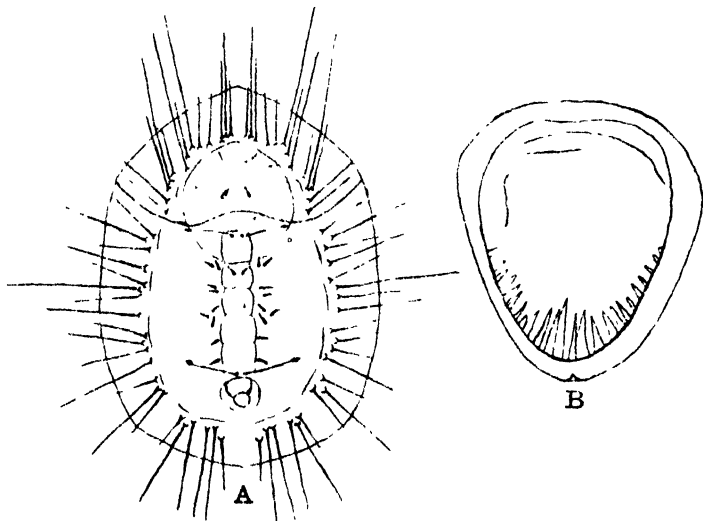


Fig. 12. *Aleurocanthus nigricans*, sp. n. : A, pupa ; B, vasiform orifice.

each group, in which the anterior is the shortest and the middle one the longest. On the cephalo-thorax on each side of the median ridge, short strong pointed spines are conspicuous. A pair of long spines just posterior to the transverse suture and another anterior to the vasiform orifice, these being swollen, almost hastate, at their apices. The long spines in the submarginal areas appear to be slightly hastate in form. Vasiform orifice on a prominent tubercle, subcordate, with posterior margin notched and with projections on inner and lateral margins ; the operculum fills the orifice.

Pundaluoya, on *Bambusa* sp. (E. E. Green).

The few specimens were badly preserved and were covered with a fungus, which made their examination difficult.

Genus ***Aleurotrachelus***, Quaintance & Baker.

Aleurotrachelus, Q. & B., Bur. Ent. U.S. Dept. Agr., Tech. Ser. 27, pt. 2, 1914, p. 103.

***Aleurotrachelus longispinus*, sp. n. (fig. 13).**

Pupa on leaf glassy yellow in colour, with a fine waxy fringe and covered with white flocculent wax material. Ovate and slightly octahedral in shape, with the anterior margin pointed ; length 0.73 mm., breadth 0.41 mm. ; a well developed keel present. Margin with double row of teeth closely apposed and difficult to differentiate ; outer row rounded and inner row more acute. The anterior end of median trachea-like ridge rather hastate. Transverse sutures to margin distinct. The

anterior portion of pupa-case near the mid-dorsal line with three pairs of long spines, the hind pair being the shortest. Pairs of small spines are seen at the anterior and posterior lateral margins and a pair at the margin posterior to the vasiform orifice. Vasiform orifice almost subcircular, with the posterior margin thickened and with a

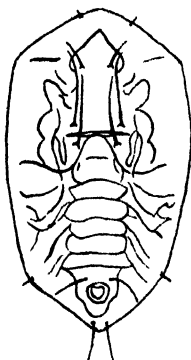


Fig. 13. *Aleurotrachelus longispinus*, sp. n.

pair of long fronto-lateral spines almost reaching the margin; operculum of similar shape, almost filling the orifice, and exposing the apex of the lingula, which is setose and carries a pair of spines.

Telloola, xi.1905, on an undetermined plant (*E. E. Green*).

Genus **Neomaskellia**, Quaintance & Baker.

Neomaskellia, Q. & B., Bur. Ent. U.S. Dept. Agr., Tech. Ser. 27, pt. 1, 1913, p. 91.

Neomaskellia bergii, Signoret.

Aleurodes bergii, Sign. Ann. Soc. Ent. France, viii, 1867, p. 395.

Aleurodes sacchari, Maskell, Trans. N.Z. Inst. xxii, 1890, p. 171.

Quaintance & Baker received specimens of this insect from Zehntner collected in Java, ii. 1897, and also from Compère from Manila on wild grass. In the British Museum there are specimens from Samoa and San Thomé. In India, sugar-cane and juar (*Sorghum*) are recorded as host-plants.

Peradeniya, 18.v.1910, on ribbed grass (*E. E. Green*).

Neomaskellia andropogonis, sp. n. (fig. 14).

Pupa flat, pale yellowish in colour, without apparent secretion and found generally along the edges of the leaf; length 1.07 mm., breadth 0.62 mm.; elongate elliptical. Margin irregularly crenulate; marginal rim present. Sixteen pairs of spines on submarginal area; on both posterior lateral margin and cephalo-thorax a pair of inconspicuous spines. Abdominal segments distinct; simple pores numerous on the five abdominal segments anterior to the vasiform orifice; pores mostly confined to mid-dorsal area. Vasiform orifice not prominently elevated as in *bergii*, transversely elliptical with posterior margin thickened; operculum twice as broad as long, about half-filling the orifice, and slightly attenuated at the junction of the lateral and posterior margins; lingula short, broadly rounded and setose; spines on lingula

not evident. Vasiform orifice with a pair of short spines mid-laterally, and in some specimens a pair of chitinised thickenings or spines latero-posteriorly.

Bandarawalla, on *Andropogon* sp., v.1906 (*E. E. Green*).

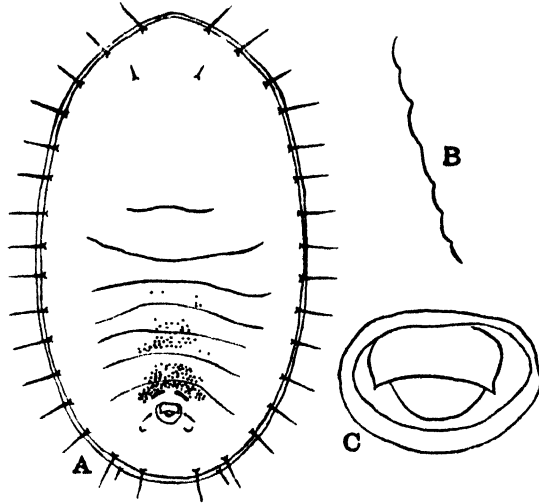


Fig. 14. *Neomaskellia andropogonis*, sp. n.: A, pupa; B, margin of pupa-case; C, vasiform orifice.

Genus **Aleurolobus**, Quaintance & Baker.

Aleurolobus, Q. & B., Bur. Ent. U.S.A. Dept. Agr., Tech. Series 27, pt. 2, 1914, p. 158.

Aleurolobus flavus, Q. & B.

Aleurolobus flavus, Q. & B., Proc. U.S. Nat. Mus. li, 1917, p. 360.

Peradeniya, on unknown tree, x.1910 (*R. S. Woglum*) ; on *Loranthus* sp. 26.v.1913 (*A. Rutherford*) ; and one specimen found on the leaf of *Loranthus* with the gall-forming *Dialeurodes loranthi*, collected at Hewheta, viii.1910 (*E. E. Green*).

Aleurolobus setigerus, Quaintance & Baker.

Aleurolobus setigerus, Q. & B., Proc. U.S. Nat. Mus. li, 1917, p. 372.

Peradeniya, vii.1913, on *Harpullia pendula*, and ix.1913, on *Harpullia* sp. (*A. Rutherford*).

Aleurolobus zeylanicus, sp. n. (fig. 15).

Pupa on leaf dense shiny black and raised by the submarginal area forming a rim. White waxy fringe present in some specimens ; obovate ; length 0.86 mm., breadth 0.35 mm. Margin crenulate, three prominent teeth present at each tracheal fold. In the submarginal area there is a ring of 14 pairs of long, fine hairs, and external to this an irregular row of inconspicuous spines ; dark brown circular markings are numerous ; submarginal suture distinct. On subdorsal area are numerous dark brown pores in irregular chain formation, and throughout the dorsal area pores of a compound nature are evident. Sutures between abdominal segments fairly distinct and the transverse suture almost reaches the submarginal suture. About twelve pairs of pores on the subdorsal area, eight pairs being situated on the abdominal

segments. Vasiform orifice situated on a tubercle, and subcordate in shape. A pair of reniform eye-spots present. A pair of fine spines near anterior margin of cephalothorax and another pair latero-anteriorly to the vasiform orifice.

Trincomali, v.1906, on an unidentified plant (*T. B. Fletcher*).

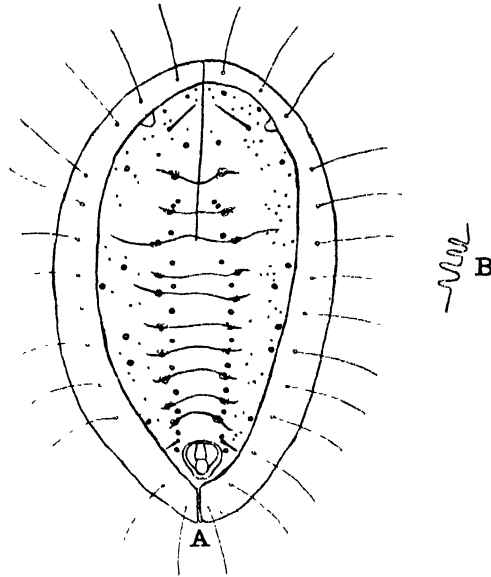


Fig. 15. *Aleurolobus zeylanicus*, sp. n.: A, pupa; B, tracheal teeth.

***Aleurolobus greeni*, sp. n. (fig. 16).**

Pupa on leaf dark brown to shiny black, without an apparent wax fringe, though in the younger stages a faint fringe of yellowish wax may be discerned. Broadly elliptical; length 1.11 mm., breadth 0.94 mm.; margin double, both dentate with

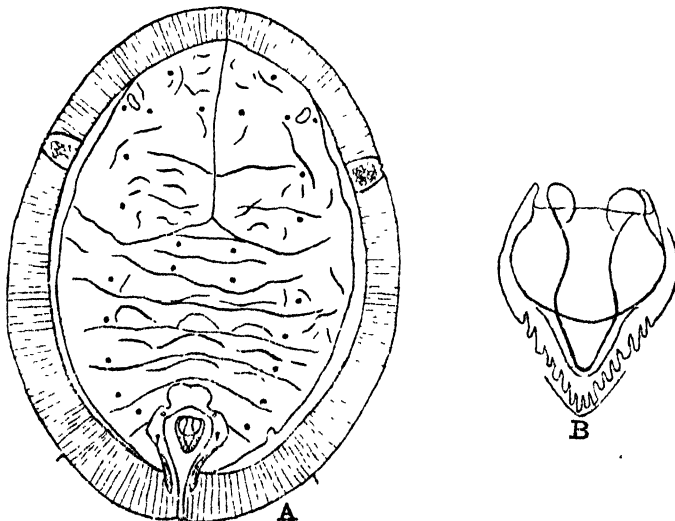


Fig. 16. *Aleurolobus greeni*, sp. n.: A, pupa; B, vasiform orifice.

square edges ; posterior lateral margin with a pair of small spines ; on submarginal area, sutures running in from margin conspicuous. A row of small spines in groups of twos runs right round the submarginal area. Tracheal and caudal folds conspicuous and terminating in a single large tooth. Tracheal pores very distinct, being rounded in shape and sculptured with polygonal markings. Submarginal suture about 0.11 mm. from margin. Transverse and abdominal sutures wavy and distinct. Dorsal area uniformly dark brown. Eye-spots reniform and transparent. On the cephalo-thorax there are six pairs of dark markings and on the abdomen seven pairs, five of them situated on the subdorsal region and two pairs posterior to the transverse suture on the mid-dorsal area. From the centre of each of these dark spots arises a small spine. The surface of the dorsal disc is sculptured and the margin incised. No conspicuous spines on dorsum. Vasiform orifice somewhat triangular, longer than broad, and the lateral margins with projections ; operculum subcordate, filling about two-thirds of the orifice, leaving the lingula exposed. The orifice is surrounded by a trilobed area, the lateral arms of which do not reach the margin.

Peradeniya, xi.1905, on an undetermined shrub (*E. E. Green*).

Genus **Tetraleurodes**, Cockerell.

Tetraleurodes, Ckll., Fla. Agr. Exp. Sta., Bull. 67, 1903, p. 664.

Tetraleurodes rugosus, sp. n. (fig. 17).

Pupa on leaf black, with well developed wax fringe and dorsum covered with wax of a flocculent nature ; oval in shape ; length 1.52 mm., breadth 0.11 mm. Margin double, outer margin rather more distinctly crenulated than inner ; anterior and posterior lateral margins each with a pair of spines. Tracheal and caudal folds represented by one tooth, caudal tooth more conspicuous. Inside the margin there is

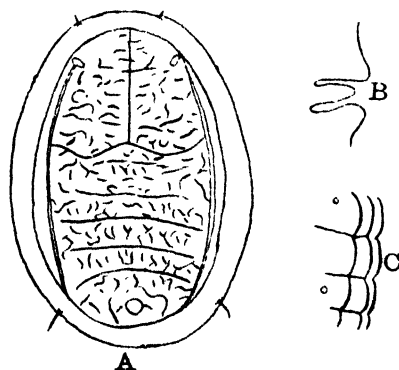


Fig. 17. *Tetraleurodes rugosus*, sp. n. : A, pupa ; B, thoracic tracheal tooth ; C, margin of pupa-case.

a ring of small pores (hairs), and interior to this a row of 13 pairs of short spines near the submarginal suture. The dorsum, with the exception of the submarginal area, rugose in appearance, and the abdominal sutures appearing black against dark brown corrugations ; medio-dorsal and transverse sutures distinct. Eye-spots reniform. Small setae occur on the dorsum, especially on cephalo-thoracic region. Vasiform orifice small and subcircular.

Dambula, 30.viii.1910 ; Maha Illupalawa, North Coast Prov., ix.1905, on grass (*E. E. Green*).

Tetraleurodes semilunaris, sp. n. (fig. 18).

Pupa on leaf with powdery wax fringe; under the microscope dark brown; elliptical; length 1.52 mm., breadth 0.90 mm. Margin crenulate; on the submarginal area there are about 60 pairs of conspicuous semilunate pores, each of which has about eleven divisions; just internally to these pores, a row of small pores (spines) and then a regular ring of about 15 pairs of spines. Submarginal suture distinct, as also are the dorso-median, transverse, and abdominal sutures; the

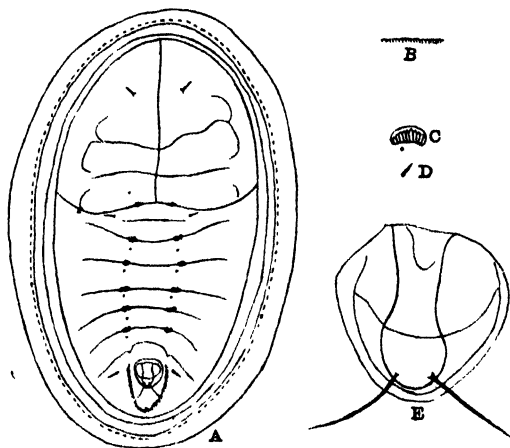


Fig. 18. *Tetraleurodes semilunaris*, sp. n. : A, pupa; B, C, D, showing relative position of the margin to a semilunate pore and a submarginal spine; E, vasiform orifice.

transverse suture turns slightly anteriorly and reaches the submarginal suture; abdominal sutures with conspicuous thickenings. Throughout the derm are small spines, the most conspicuous being a pair on the cephalo-thorax, a pair posterior to the transverse suture, and a pair beside the vasiform orifice. Vasiform orifice subcordate; operculum filling about two-thirds of the orifice; lingula exposed, setose and armed with two long hairs at its distal end. A distinct furrow running from the lateral anterior margins of vasiform orifice to the submarginal suture.

Colombo, xi.1903, on citronella grass (*Cymbopogon* sp.) (E. E. Green).

Genus **Zaphanera**, nov.

Pupa-case with a double row of marginal teeth; submarginal area not separated from dorsal disc; thoracic and caudal folds indicated but not distinct; rhachis prominent and abdominal sutures distinct; cephalo-thorax with a well-defined median area; no prominent setae on dorsum but small circular pores present; vasiform orifice elevated, subcordate, filled by operculum, lingula obscured.

Genotype, *Zaphanera cyanotis*, sp. n.

Near to *Aleurotrachelus*, Q. & B., but differing in the presence of dorsal pores, and the elevated vasiform orifice.

Zaphanera cyanotis, sp. n. (fig. 19).

Pupa on leaf shiny black, with white marginal fringe and pronounced white wax secretion along mid-dorsal line. Length 1.48 mm., breadth 1.01 mm.; ovate with slight constrictions in the region of the thoracic folds. Margin double, with outer edge more

conspicuously dentate ; a row of small pores runs round the margin of the pupa-case ; interior to this row and within the light brown portion of the case, there is a row of five or six small pairs of pores, one pair situated at the thoracic folds. Thoracic folds indicated by the depressions at the margin and by slight waxy sutures running inwards from the margin. The caudal fold made prominent by its lighter colour, the margin at its termination slightly protruding and armed with two long spines.

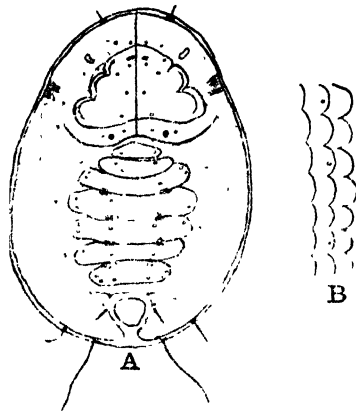


Fig. 19. *Zaphanera cyanotis*, gen. et sp. n. : A, pupa ; B, margin of pupa-case

Transverse and cephalo-thoracic sutures distinct. Demarcated area in cephalo-thorax with about seven pairs of small pores ; reniform eye-spots present ; a dark brown area, composed of dark brown irregular circular spots, is conspicuous between the light brown marginal area and the rhachis. Rhachis very prominent, and there are rows of small pores situated subdorsally and mid-dorsally. Beside the rhachis a row of small pores may be seen and also near the marginal area. The abdominal sutures with chitinated thickenings. Vasiform orifice subcordate, with a pair of spines latero-anteriorly and a prominent pair latero-posteriorly. A pair of small setae may be seen at the latero-anterior and latero-posterior margins.

Maskeliya, v.1911, on *Cyanotis* sp. (J. Pole) ; Pundaluoya, on *Cyanotis* sp. (E. E. Green).

Genus *Laingiella*, nov.

Pupa-case of medium size, fringed ; margin with a double row of teeth ; sub-marginal area with wax tubes well developed and not separated from sub-dorsal area ; dorsal area with small compound pores ; tracheal and caudal folds absent ; vasiform orifice elevated, well filled by operculum, subcordate, lingula included.

Genotype, *Laingiella bambusae*, sp. n.

This genus would appear to have affinities with *Paraleyrodes*, Quaint., but may be distinguished from it by the double row of marginal teeth and by the difference in shape of the vasiform orifice and lingula.

Laingiella bambusae, sp. n. (fig. 20).

Pupa on leaf black and made conspicuous by its white fringe. Length 0.99 mm., breadth 0.74 mm. ; elliptic in outline. Margin with a double row of teeth, the outer margin more prominent ; submarginal area differentiated from the sub-dorsal area by a ring of seemingly transverse linear lines (thickened terminations of the sutures

of the wax tubes) this ring being about 0.17 mm. from the margin. The sutures at the vasiform orifice are distinct and do not reach the margin. An uneven toothed line runs round the pupa-case at about 0.06 mm. from the margin, and up to this line the sutures from the margin are very distinct; on each side of these sutures dark brown markings are evident. An interrupted thickened chitinised fold runs round the pupa-case between the margin and the line of demarcation caused by the sutures. There are nine pairs of small compound pores forming a ring in the sub-dorsal area;

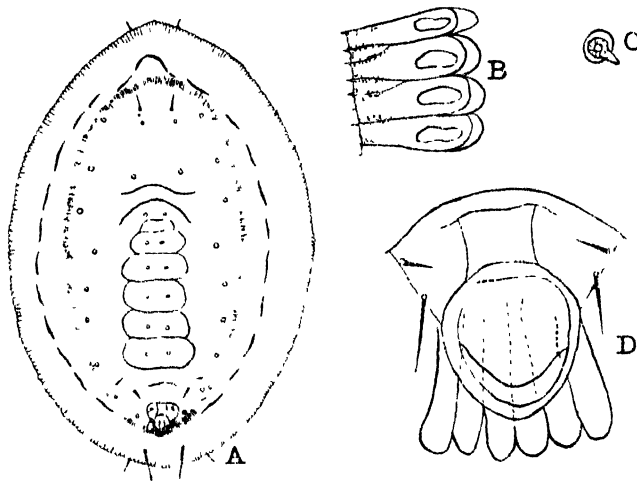


Fig. 20. *Laingiella bambusae*, gen. et sp. n.: A, pupa; B, margin of pupa-case; C, pore; D, vasiform orifice.

anterior to the transverse suture there are two more pairs of the same size, and anterior to these a smaller pair. In addition to the above-named pores, six pairs are situated on the dorsal ridge. Smaller inconspicuous pores may be seen on the dorsum. A pair of spines on the anterior and latero-posterior margin, a pair on the cephalo-thorax, four pairs latero-anteriorly of vasiform orifice, and one pair posteriorly on the sub-marginal area. The vasiform orifice subcordate; operculum filling the orifice and obscuring the lingula.

Ratnapura, on bamboo, 15.x.1909 (E. E. Green).

ON SOME TROPICAL COPEOGNATHA, ESPECIALLY FROM THE FIJI ISLANDS.

By H. H. KARNY,
Buitenzorg, Dutch East Indies.

The present paper reports on a few Copeognatha received by the author for determination from the Imperial Bureau of Entomology, for which I am very much indebted to the kindness of the Director, Dr. Guy A. K. Marshall. Unfortunately all the specimens were dried and carded, so that it is impossible in some cases to give as full descriptions as are desirable for complete characterisation of the species, and as would have been done if there had been alcohol material at my disposal. Nevertheless, it seems desirable to record all the species before me, as nothing has been known hitherto regarding the Copeognath fauna of the Fiji Islands.

Family MYOPSOCIDAE.

Lichenomima muscosa (Enderlein).

One specimen before me, from Fiji, Labasa (*R. Veitch*, vii.1921), agrees perfectly in all details with the description and figure given by Enderlein, except that it is slightly smaller, the fore wings being only 3.8 mm. long, instead of 5 mm. Length of hind tarsal joints: i, 0.52 mm.; ii, 0.07 mm.; iii, 0.09 mm. First joint with 22 ctenidia.

As to the shape of the areola postica (cubital cell), the species seems to be intermediate between *Lichenomima* and *Myopsocus*. When Enderlein described it, he placed it in the latter genus, because the former was not yet erected. When characterising *Lichenomima* (1910), he did not say whether *muscosa* should remain in *Myopsocus* or should be transferred to *Lichenomima*. I prefer to place it in the latter, because it seems to be closely related to the Malayan *Lichenomima sumatrana*.

The species was originally described from Japan (Tokyo).

Family PSOCIDAE.

Psocus nebulosus (Stephens).

Two specimens of this widely spread species (Europe, India, Africa) from Ibadan, Nigeria (18.viii.1922). They agree perfectly with the characters of European specimens, especially as to the number of ctenidia (Enderlein, Ann. Mus. Nat. Hung., i, p. 217, 1903). Pterostigma somewhat paler brown in basal half. M+Cu dark brown distad, as in var. *usambaranus*, Enderlein, but without a dark spot there; M+Cu₁ pale, whitish hyaline basad, dark brown distad; bases of both branches of Rs, and the whole of Cu₂ also pale. Otherwise all veins dark.

Psocus (Amphigerontia) vitiensis, sp. n.

General colour very dark castaneous brown. Head uniformly coloured; eyes black. Antennae reddish brown basad, then darker, grey brown. Thorax dark castaneous, slightly paler in the middle, and gradually becoming more yellowish brown on the lateral lobes. Abdomen castaneous, blackish in basal part of each segment. Legs paler than the body, ferruginous. Hind tibiae cylindrical, *i.e.*, without wing-like expansions as in *Podopterocus*, furnished with stout bristles. Hind tarsi unfortunately broken off in the unique type specimen.

Wings (fig. 1) hyaline, with the following dark, brownish black markings: basal third of axillar cell, apex of anal cell, base, fore margin and apical part of pterostigma. Veins dark, with the following portions pale: anal vein, except at apex; Cu₂ and

extreme base of Cu_1 ; M close before junction with Cu_1 ; apex of Rs, stem at bifurcation and bases of both fork branches. Pterostigma obtusangulate at hind margin. Rs connected with M by a very short cross-vein. Fork of Rs about three times as long as the pedicel, rather narrow and nearly parallel-sided, marginal distance between R_{2+3} and R_{4+5} somewhat more than twice as long as the distance between R_{4+5} and M_1 . Discal cell nearly twice as long as wide, narrowed below. Areola postica much longer at hind margin than high, moderately broad above; the ascending part of Cu_1 distinctly longer than $M+Cu_1$.



Fig. 1. Fore wing of *Psocus (Amphigerontha) vitiensis*, sp. n.

In the hind wings, the base of Rs, the base of M and Rs + M are of about equal length (the base of M being conspicuously longer in *P. lignicola*). R_{2+3} about as long as the fork pedicel, R_{4+5} distinctly longer. Marginal distance between R_{2+3} and R_{4+5} about as long as R_{2+3} ; marginal distance between R_{4+5} and M hardly half as long. M (after junction with Rs) curved at base, then nearly straight and about parallel with R_{4+5} .

Length of fore wing 3.4 mm.

One specimen from Nadi, Fiji, 1916 (*R. Veitch*).

This new species resembles in general appearance *P. similis*, Banks (Singapore), *P. javanicus*, Enderlein (Java) and *P. lignicola*, Enderlein (Australia, N.S.W.). In the former M and Rs meet at a single point on the fore wings, in *javanicus* and *lignicola* they are united for some distance, whilst in *vitiensis* they are connected by a very short cross-vein. But this character must not be overrated, as it is known to vary sometimes in different specimens of the same species. But there are also other differences between my new species and the three named above. The hind margin of the pterostigma is shallow and broadly rounded in *javanicus* and *lignicola*, obtusangulate in *vitiensis*, right-angled in *similis*. The areola postica of *vitiensis* is longer and not so high as in *similis*, and narrower above than in *javanicus* and *lignicola*. The radial fork of *vitiensis* is longer and narrower than in all these three species. As to the colouration of the fore wings, it agrees rather well with that of *similis*, whilst differing from that of *javanicus* by the absence of the dark stripe behind the pterostigma, and from *lignicola* by the absence of the dark spot at $M+Cu$. The size of all these four species is approximately the same, *vitiensis* being slightly larger than the others.

Family CAECILIIDAE.

Key to the Indo-Australian Species of Epipsocus.

1. Fore wings pale yellowish brown or rose-coloured or blackish; veins at the base of every bristle with a dark dot 2
Fore wings hyaline with brown stripes or spots, or yellowish or brownish hyaline, never with dark dots on veins at the bristle bases 4
2. Fore wings blackish, with irregular brownish spots (Queensland) *funestus*, End.
Fore wings paler 3
3. Fore wings rose-coloured (Ceylon) *roseus* (Hag.)
Fore wings pale yellow-brown (New South Wales) *villosus*, End.

4. Fore wings reduced, about half as long as the body ; hind wings wanting (Malay States) *murcus*, End.
Wings not reduced ; fore wings nearly as long as the body or longer ... 5
5. Fore wings with a distinct, continuous cross-band near base, through the middle or along apical margin 6
Fore wings without distinct, continuous cross-bands 10
6. Fore wings with a sub-basal, brown cross-band only, between base of stigma and nodulus (Ceylon) *fuscofasciatus*, End.
Fore wings with a cross-band along apical margin 7
7. Besides the apical cross-band, there are only small brown spots at the ends of veins, at the nodulus, in the pterostigma and at the end (furcation) of M+Cu (New Guinea) *marginatus*, End.
Brown colour on fore wings more extended 8
8. Fore wings with small brown spots at the ends of veins, with a brownish basal cross-band and an apical band (Ceylon) *delicatus*, (Hag.)
Fore wings brown also across the middle 9
9. A broad band before middle, and one at about middle across stigma rather obliquely to the areola postica, its outer margin distinct ; areola postica mostly dark, and thence along outer margin a broad dark area, leaving a pale spot in base of second median fork : the radial fork with only a band across it and a dot at base (Philippines : Luzon) *completus*, Banks
General colour of fore wings pale brownish, with some larger, hyaline spots between the veins and along the apical margin ; the brownish colour somewhat darker in four irregular, nebulous bands across the wing ; at the marginal ends of all veins a small dark brown spot (Borneo : Sarawak)
nubilipennis, Karny
10. Fork of radial sector plainly longer than its pedicel 11
Fork of radial sector about as long as or even shorter than its pedicel ... 12
11. Fore wings uniformly pale yellowish brown ; small dark spots at the ends of all veins and in the basal part of pterostigma ; radial sector of hind wings connected with median by a short cross-vein, not united with M for some distance (Borneo : Sarawak) *dubius*, Karny
Fore wings of a nearly uniform brown tint, tips of veins with blackish spots ; hind wings not described by the author (Philippines : Luzon)
sumipennis, Banks
12. Fore wings hyaline, with numerous dark dots, and dots at ends of veins, a cloud along median, and one partly above partly within the areola postica (Assam)
conspersus, Banks
Surface of fore wings without numerous dark dots 13
13. A long, narrow, brown streak along costa from base of stigma to tip of fore wing, and the ends of veins along the hind border each with a black spot (India : Rotung) *costalis*, Banks
No dark stripe along apical half of fore margin 14
14. Medial vein and radial sector joined by a long cross-vein, about as long as width of the stigma 15
Medial vein and radial sector nearly touching one another at one point, connecting vein between them unusually short 16
15. Fork of radial sector very short, hardly half as long as pedicel (Singapore)
hyalinus, Banks
Fork of radial sector about as long as pedicel (Philippines : Luzon)
inornatus, Banks

16. Radial fork shorter and less divergent : R_{4+5} distinctly shorter than the pedicel ; marginal distance between R_{2+3} and R_{4+5} shorter than that between stigma and R_{2+3} , about half as long as R_{2+3} (Tahiti) ... *tahitiensis*, sp. n.
 Radial fork longer, strongly divergent : R_{4+5} about as long as the pedicel ; marginal distance between R_{2+3} and R_{4+5} twice as long as that between stigma and R_{2+3} , as long as R_{2+3} (Japan : Kyoto) ... *fasciicornis*, Okamoto

***Epipsocus tahitiensis*, sp. n.**

General colour pale reddish-brown ; antennae and legs yellowish. Thorax pale yellow-brown, with a large nebulous, dark brown spot above in the middle. Antennae closely set with long stiff bristles, which are four or five times as long as the antennal joint is wide. Hind tarsi (?).

Fore wings (fig. 2) yellowish hyaline, with yellow veins ; all, except An, set with two rows of long, pale bristles ; bristles at apical margin crossing one another. Across the pterostigma there is a nebulous, greyish cross-band reaching from fore margin to hind margin of pterostigma. A similar band across areola postica reaches from hind margin to medial vein. Distad from these cross-bands, Rs and M are dark. The stigma sac and the base of Rs and its connection with M are also

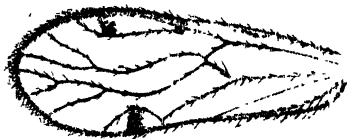


Fig. 2. Fore wing of *Epipsocus tahitiensis*, sp. n.

blackish ; distad from here, Rs is yellowish, till the dark apical half. Pterostigma long and rather narrow, not angulated at hind margin, but evenly rounded. Connecting vein between Rs and M unusually short, as in the Japanese *fascipennis*. Pedicel of radial fork about one and a half times as long as the fork branches ; these not strongly diverging, the marginal distance between them slightly shorter than that between stigma and R_{2+3} , and about half as long as this vein. Areola postica rather high, but much shorter and somewhat higher than the stigma.

Hind wings normal to the genus ; radial sector and media broadly united with one another for a distance which is about as long as the bases of Rs and M together ; base of M about one and a half times as long as that of Rs. Hind branch (R_{4+5}) of Rs about as long as the pedicel of the fork, running almost parallel with the fore margin and medial vein. Fore branch (R_{2+3}) much shorter, strongly diverging against the fore margin.

Length of fore wing, 2.5 mm.

Described from the unique type specimen from Oceania, Tahiti, 6.iii.1921 (H.W. Simmonds).

***Pseudocaecilius marshalli*, sp. n.**

Very near to the Japanese *P. solocipennis*, from which it may be distinguished especially by the following characters :—

General colour dark orange-yellow ; eyes black, broadly bordered all round with brownish yellow, not hairy, much smaller than the space between them. Front and vertex set with some long, stiff bristles, which are pale basally, blackish distally. Antennae orange-yellow in basal part, then gradually becoming darker, brownish distally ; rather closely set with long, stiff bristles, which are about four times as long as the antennae are broad. Legs yellow ; femora darker than tibiae and tarsi, yellowish brown. First hind tarsal joint with about 15 ctenidia. Length of hind tibia 0.77 mm. ; first hind tarsal joint, 0.28 mm., second joint, 0.08 mm.

Fore wings (fig. 3) uniformly greyish hyaline, with yellow veins, which are set with two rows of long, stiff bristles. M and Cu₁ also with two rows of bristles; An without bristles. Pterostigma long and narrow, with evenly rounded hind margin; surface

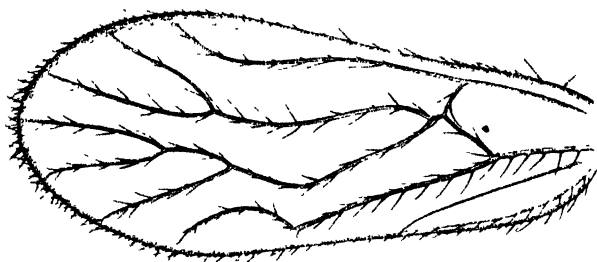


Fig. 3. Fore wing of *Pseudocaecilius marshalli*, sp. n.

(between Cu and R) not bristled. Rs and M united with one another for a very short distance. Pedicel of radial fork about one and a half times as long as R₂₊₃; fork rather narrow, branches moderately diverging. Arcola postica as usual in this genus, about twice as long as high, with broadly rounded fore margin (Cu₁).

Hind wings hyaline; Rs and M united for a distance about as long as the base of M; base of Rs slightly shorter. Pedicel of radial fork about as long as its hind branch (R₄₊₅).

Length of fore wing, 1.9 mm.

The unique type specimen was taken at Lautoka, Fiji, on young cotton, 2.vi.1923 (*R. Veitch*).

I have pleasure in naming this new species in honour of Dr. Guy A. K. Marshall, Director of the Imperial Bureau of Entomology, to whom I am indebted for the opportunity of studying this interesting material.

***Pseudocaecilius veitchi*, sp. n.**

Body uniformly dark brown, almost blackish; antennae also dark. Surface of head and antennae set with long, stiff bristles. Legs dark brown. First hind tarsal joint with about 15 ctenidia, 0.21 mm. long; second joint, 0.09 mm. long.

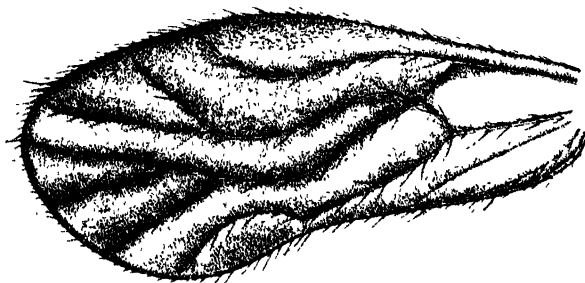


Fig. 4. Fore wing of *Pseudocaecilius veitchi*, sp. n.

Fore wings (fig. 4) dark brown, gradually becoming paler basally, more greyish hyaline. Veins dark brown, set with two rows of long, stiff bristles (except anal vein). Pterostigma long and rather narrow, with broadly rounded hind margin; whole surface closely set with short bristles. Radial sector united with medial vein for a very short distance. Pedicel of radial fork somewhat more than one and a half times as long as R₂₊₃; fork branches strongly diverging; marginal distance between R₂₊₃

and R_{4+5} longer than that between stigma and R_{2+3} , and more than twice as long as that between R_{4+5} and M_1 . Areola postica as usual in this genus.

Length of fore wing, 1.9 mm.

Named after its discoverer, Mr. R. Veitch, who collected the unique type specimen at Labasa, Fiji, vii.1922.

Differing from all the hitherto known species by the dark fore wings and the strongly diverging branches of the radial sector.

***Pseudocaecilius greenwoodi*, sp. n.**

General colour practically as in the preceding species. Eyes as in *marshalli*, viz., black and broadly bordered with ferruginous all round. Coxae and legs pale yellowish. Hind tibiae more brownish yellow; first hind tarsal joint pale yellowish, second joint gradually becoming darker distally, blackish brown at apex (incl. claws). First hind tarsal joint with about 15 ctenidia, 0.22 mm. long; second joint, 0.11 mm. long.

Fore wings (fig. 5) uniformly dark grey brown, except two large, whitish-hyaline, rounded-triangular spots; one at fore margin at the end of pterostigma, not reaching radial sector; the other at hind margin, at the base of first and apex of second cubital cell, reaching forwards across medial vein to the middle of the wing. Veins dark, set with two rows of bristles, except anal vein. Pterostigma shaped practically as in both preceding species, set with bristles in anterior (costal) half only (and along



Fig. 5. Fore wing of *Pseudocaecilius greenwoodi*, sp. n.

radial vein). Radial sector and medial vein united for a very short distance. Pedicel of radial fork not quite one and a half times as long as the fore branch (R_{2+3}); fork rather narrow, marginal space between the branches less than that between stigma and R_{2+3} , and about equal to that between R_{4+5} and M_1 . Areola postica of usual shape, comparatively larger than in the preceding species.

Length of fore wing, 1.8 mm.

Named in honour of its discoverer, Mr. W. Greenwood, who took the unique type specimen at Loloti, Fiji, 19.xii.1920.

Similar in general appearance to the preceding species, but differing by the two large hyaline spots on the fore wings and by some details of the venation, especially by the much narrower radial fork.

***Caecilius novoguineensis*, Enderlein.**

Two specimens from Labasa, Fiji, vii. and ix.1922 (R. Veitch). The species was known hitherto from New Guinea only.

***Ectopsocus (Micropsocus) myrmecophilus*, Enderlein.**

Lautoka, Fiji, 10.vii.1922, from jar containing fruits of *Jatropha curcas* (W. Greenwood); and Labasa, Fiji, 31.viii.1922 (W. Greenwood). Hitherto known from India and New Britain.

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology, between 1st July and 30th September, 1925, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

ASSISTANT DIRECTOR OF AGRICULTURE, BARBADOS :—150 Mites ; from the British West Indies.

ASTRAKHAN STATION FOR PLANT PROTECTION :—482 Orthoptera ; from Astrakhan, Russia.

Mr. E. BALLARD :—31 Diptera, 42 Parasitic Hymenoptera, 8 Rhynchota, and 2 Orthoptera ; from Queensland.

Mr. H. S. BARBER :—2 Curculionidae ; from the United States of America.

Mr. G. E. BODKIN, Government Entomologist :—22 Diptera, 2 Coleoptera, 11 Hymenoptera, 50 Lepidoptera, 4 Orthoptera, and 11 Ticks ; from Palestine.

Dr. H. S. DE BOER :—112 Siphonaptera ; from Kenya Colony.

Dr. G. BONDAR :—11 Diptera, 61 Coleoptera and 3 larvae, 8 Parasitic Hymenoptera, 2 Lepidoptera and 4 larvae, 194 Isoptera, and 2 Orthoptera ; from Brazil.

Mr. L. L. BUCHANAN :—1 Curculionid ; from Porto Rico.

Dr. P. A. BUXTON :—15 Diptera, 51 Coleoptera, 19 Hymenoptera, 260 Isoptera, 10 species of Coccidae, 53 other Rhynchota, 100 Psocidae, 22 Orthoptera, 36 Spiders, and 3 Scorpions ; from New Hebrides and New Caledonia : and 65 Culicidae, 13 Psychodidae, 303 other Diptera, 121 Coleoptera, 22 Hymenoptera, 67 Lepidoptera, 115 Rhynchota, 31 Orthoptera, and 4 Planipennia ; from Samoa.

Mr. E. C. CHUBB :—48 Diptera ; from Natal.

Dr. A. CONNALL :—34 Tabanidae ; from Southern Nigeria.

Mr. G. S. COTTERELL :—15 Diptera, 9 Coleoptera, 2 Hymenoptera, 16 Lepidoptera, 17 Rhynchota, and 4 Chrysopidae ; from the Gold Coast.

Dr. H. SILVESTER EVANS :—2 Coleoptera ; from Fiji.

Prof. J. C. FAURE :—3 *Glossina*, 5 Tabanidae, 3 other Diptera, 525 Coleoptera, 2 Hymenoptera, 51 Rhynchota, and 3 Trichoptera ; from South Africa.

Mr. T. BAINBRIDGE FLETCHER, Imperial Entomologist :—549 Coleoptera and 4 Odonata ; from India.

Mr. C. FRENCH, JUNR. :—12 species of Coccidae ; from Victoria, Australia.

Mr. F. D. GOLDING :—14 Diptera, 88 Coleoptera, 6 Hymenoptera, 14 Lepidoptera, 44 Rhynchota, and 6 Orthoptera ; from Southern Nigeria.

GOVERNMENT ENTOMOLOGIST, KUALA LUMPUR :—84 Coleoptera, 14 Parasitic Hymenoptera, 90 other Hymenoptera, 264 Lepidoptera, 6 species of Aphidae, and 21 other Rhynchota ; from the Federated Malay States.

Mr. W. B. GURNEY :—520 Mites ; from New South Wales.

Mr. G. L. R. HANCOCK :—2 *Glossina*, 27 other Diptera, 160 Coleoptera, 58 Parasitic Hymenoptera, 76 other Hymenoptera, 10 Lepidoptera, 3 species of Coccidae, 39 other Rhynchota, and 2 Orthoptera ; from Uganda.

Mr. E. HARGREAVES, Government Entomologist :—8 Culicidae, 8 *Glossina*, 3 Tabanidae, 5 *Stomoxys*, 33 other Diptera, 390 Coleoptera, 287 Hymenoptera, 41 Lepidoptera, 15 species of Coccidae, 10 Psyllid larvae, 365 other Rhynchota, 42 Orthoptera, 6 Plecoptera, 5 Hemerobiidae, 6 Perlidae, and 4 Trichoptera ; from Sierra Leone.

Major R. W. G. HINGSTON :—3 Orthoptera ; from Central India.

Mr. G. H. E. HOPKINS :—62 Diptera, 12 Coleoptera, 3 Hymenoptera, 7 Lepidoptera, 13 Rhynchota, and 6 Orthoptera ; from Samoa.

Rev. J. W. HUNT :—514 Curculionidae ; from Kenya Colony.

Dr. A. INGRAM :—60 Siphonaptera, 100 Culicidae, 2 other Diptera, 6 Coleoptera, and 4 Rhynchota ; from South Africa.

INSPECTOR-GENERAL OF AGRICULTURE, BAGHDAD :—69 Siphonaptera, 173 Coleoptera, 5 Parasitic Hymenoptera, 7 Lepidoptera, 41 Rhynchota, 41 Orthoptera, 3 Chrysopidae, and 20 Mites ; from Iraq.

Mr. E. JACOBSON :—433 Curculionidae ; from Sumatra.

Mr. O. B. LEAN :—5 Diptera, 6 Coleoptera, 8 Parasitic Hymenoptera, and 5 Lepidoptera ; from Southern Nigeria.

Dr. LL. LLOYD :—7 Diptera, 2,326 Coleoptera, 231 Hymenoptera, 43 Lepidoptera, 591 Rhynchota, 415 Orthoptera, 34 Planipennia, and 80 Odonata ; from Northern Nigeria.

Mr. G. A. MAVROMOUSTAKIS :—2 Tabanidae, 101 other Diptera, 66 Coleoptera, 12 Hymenoptera, 61 Lepidoptera, 6 Rhynchota, and 469 Orthoptera ; from Cyprus.

Dr. R. E. MCCONNELL :—2 *Tabanus*, and 4 Ticks ; from Colombia, South America.

MUSEUM D'HISTOIRE NATURELLE, PARIS :—248 Cercopidae ; from South America.

Mr. J. G. MYERS :—10 Diptera, 99 Parasitic Hymenoptera, and 68 Rhynchota ; from France.

NATAL MUSEUM, PIETERMARITZBURG :—254 Coleoptera ; from South Africa.

NATIONAL MUSEUM, MELBOURNE :—3 Culicidae, 14 other Diptera, 7 Parasitic Hymenoptera, 4 species of Coccidae, 152 other Rhynchota, a number of Mallophaga, and 17 Mites ; from Australia.

Mr. A. J. NICHOLSON :—50 Coleoptera, 10 Hymenoptera, and 788 Orthoptera ; from New South Wales.

Mr. L. OGILVIE, Plant Pathologist :—2 Tabanidae, 96 other Diptera, 42 Coleoptera, 102 Parasitic Hymenoptera, 100 other Hymenoptera, 172 Lepidoptera, 30 Thysanoptera, 6 species of Aphidae, 9 species of Coccidae, 100 other Rhynchota, 5 Psocidae, 4 Orthoptera, 13 Odonata, 3 Chrysopidae, and 6 Mites ; from Bermuda.

Mr. W. H. PATTERSON, Government Entomologist :—185 Isoptera ; from the Gold Coast.

Mr. A. W. J. POMEROY, Government Entomologist :—20 Diptera and 9 pupa-cases, 28 Coleoptera and 15 larvae, 65 Parasitic Hymenoptera, 280 Lepidoptera, 42 larvae, 2 pupae, 39 pupa-cases, and 96 cocoons, and 3 Rhynchota ; from Southern Nigeria.

Mr. Y. RAMACHANDRA RAO, Government Entomologist :—54 Diptera, 2 Curculionidae, and 39 Lepidoptera ; from South India.

Mr. F. G. RHYNEHART :—3 Coleoptera and 11 Rhynchota ; from North Ireland.

Mr. A. H. RITCHIE, Government Entomologist :—104 Diptera and 13 early stages, 208 Coleoptera, 15 Parasitic Hymenoptera, 24 other Hymenoptera, 198 Lepidoptera and 10 larvae, 50 Thysanoptera, 49 Rhynchota, 11 Orthoptera, 4 Chrysopidae, and a number of Mites ; from Tanganyika Territory.

Prof. Dr. W. ROEPKE :—2 Lepidoptera and 2 pupa-cases ; from Java.

Dr. M. SALFI :—38 Orthoptera ; from Italy.

Mr. H. W. SIMMONDS :—2 Tabanidae, 32 other Diptera, 54 Coleoptera and 3 early stages, 8 Parasitic Hymenoptera, 44 other Hymenoptera, 33 Rhynchota, and 5 Orthoptera ; from the Federated Malay States : and 12 Parasitic Hymenoptera, and 3 Spiders ; from Fiji.

Mr. H. P. THOMASSET :—9 Culicidae, 82 other Diptera, 14 Coleoptera, 46 Hymenoptera, 17 Lepidoptera, 24 Rhynchota, 8 Orthoptera, and 5 Ephemerae ; from Natal.

Mr. R. VEITCH :—12 Coleoptera and 80 Parasitic Hymenoptera ; from Fiji.

WELLCOME TROPICAL RESEARCH LABORATORIES :—92 Cimicidae, 80 Jassidae, 297 Orthoptera, 50 Collembola, and 100 Mites ; from British Sudan.

Mr. R. SENIOR WHITE :—1 Pentatomid bug ; from Ceylon.

Mr. D. S. WILKINSON, Government Entomologist :—34 Tachinidae, 310 Coleoptera, 24 Parasitic Hymenoptera, and 12 Microlepidoptera ; from Cyprus.

Mr. G. N. WOLCOTT :—69 Coleoptera ; from Haiti.

Dr. F. ZACHER :—12 Coleoptera ; from Germany.

ADDITIONAL NOTES ON THE NOMENCLATURE OF AUSTRALIAN TABANIDAE.

By EUSTACE W. FERGUSON, M.B., Ch.M. (Syd.).

The previous paper on the nomenclature of Australian TABANIDAE (Ferguson, 1924) was unfortunately despatched for publication long before Enderlein's paper "Ein neues Tabaniden-system" (Enderlein 1922) became available in Sydney. Hence certain alterations are necessary to statements which appear in my former paper.

More important still was the unfortunate oversight of a paper by Coquillett (1910) on the type species of North American genera of Diptera. In this latter paper the type species are designated for all of Walker's subgenera of *Pangonius* and hence my designations of the same become valueless.

Comparison of the species designated as types in each instance show, however, divergence in only three genera. These are *Nuceria*, Walker, *Melpia*, Walker, and *Erephopsis*, Rondani.

As type of *Nuceria* Coquillett designated *P. longirostris*, Hardw., a species commonly placed in *Corizoneura*, which name therefore *Nuceria* must replace. It was to obviate this change that, in ignorance of Coquillett's designation, I designated the third species (*rostrata*) as genotype.

Melpia. The genotype designated by Coquillett is *P. fulvithorax*, Wied. As, however, this appears to belong to the same group of species as the genotype designated by myself (*rufohirta*, Walk. =) *nigripennis*, Guér., no alteration appears necessary in regard to Australian species, none of which can be regarded as falling in this genus.

Erephopsis. The same species (*P. fulvithorax*, Wied.) was selected by Coquillett as genotype of *Erephopsis*, Rondani. This name thus becomes a synonym of *Melpia* and cannot therefore be applied to Australian species. It might be noted incidentally that Enderlein quotes *P. fulvithorax*, Wied., as the genotype of *Sackenimyia*, Bigot, 1879.

It is rather curious that in the case of these three genera (*Nuceria*, *Melpia* and *Erephopsis*) the genotypes designated by Enderlein also differ from those designated by Coquillett. These differences have already been commented upon by Bequaert (1924), and it is to the latter's paper that I am indebted for knowledge of the prior designations made by Coquillett. It would almost seem as if Brèthes (1914) and Austen (1920) had also overlooked Coquillett's designations.

Bequaert has also dealt at some length with the classification proposed by Enderlein in so far as it affects American and African species. It now becomes necessary to analyse Enderlein's paper in so far as Australian species are concerned. The proposal to erect the two subfamilies generally accepted—PANGONINAE and TABANINAE—into major divisions—Opistacanthae and Opistanoplae—with the further subdivision of each into subfamilies and tribes seems to be of doubtful value. Furthermore, the characters used in certain instances appear to me of questionable validity. It remains yet to be seen whether these will meet with acceptance by entomologists.

In view of the nomenclatorial changes proposed it is important to determine under what genera Australian species will fall.

The generic names used by Enderlein of which the genotypes designated by him are Australian species are 12 in number—*Pelecorrhynchus*, Macq., *Apocampta*, Schiner, *Copidapha*, Enderl., *Corizoneura*, Rond., *Scaptia*, Walk., *Triclista*, Enderl., *Erephopsis*, Rond., *Plinthina*, Walk., *Lilaea*, Walk., *Ectenopsis*, Macq., *Ommia*, Enderl., *Dasybasis*,

Macq. To these must be added *Cryptoplectria*, Enderl., *Paracanthocera*, Enderl., and *Holcopsis*, Enderl., proposed in a later paper (Enderlein 1923).

Other endemic Australian genera unknown to Enderlein are *Palimmecomyia*, Taylor, *Phibalomyia*, Taylor (= *Elaphromyia*, Taylor, nom. praeocc.), *Pseudotabanus*, Ricardo, *Pseudopangonia*, Ricardo, *Coenoprosopon*, Ricardo, *Demoplatus*, Ricardo, *Parasilvius*, Ferguson, and *Cydistomyia*, Taylor. The extra-Australian genera are *Oscia*, *Buplex*, *Silvius*, *Chrysops*, *Tabanus* and *Stibasoma*.

These genera are included in seven subfamilies—PELECORRHYNCHINAE, MELPIINAE, PANGONIINAE, SILVIINAE, TABANINAE, DIACHLORINAE and HAEMATOPOTINAE. I have already expressed the opinion that the character of the cell R_5 , i.e., whether closed or open, is not of generic value; nevertheless Enderlein has used it as the differential character for separating his subfamilies MELPIINAE and PANGONIINAE. By its use one finds species that are obviously closely allied in every other way separated into two different subfamilies. I propose therefore to consider together all the Australian genera which are included by Enderlein in these two subfamilies. These are as follows:—

Apocampta, *Copidapha*, *Corizoneura*, *Oscia*, and *Scaptia*, in MELPIINAE; and *Triclistia*, *Erephopsis*, *Plinthina* and *Lilaea*, in PANGONIINAE.

These genera include the bulk of the Australian Pangoniine species, the majority of which are hairy-eyed. According to Enderlein's table the bare-eyed species of the group would fall into either *Copidapha* or *Corizoneura*. The former genus is, however, based on an undescribed species, *C. bifasciatus*, and must be regarded at present as a *nomen nudum*. From the characters given in the generic key one might hazard the opinion that the species is identical with *Corizoneura conspicua*, Ricardo, an insect which is not congeneric with other Australian species formerly placed in *Corizoneura*, and should be relegated to the hairy-eyed group, as the eyes are densely haired in the male.

As type of *Corizoneura*, Enderlein designated "*C. angustata* (Macq. 1847) Australien." Presumably *angusta*, Macquart, is intended, and this is now included in *Ectenopsis* (*vide infra*). In any case *Corizoneura* is not admissible for our Australian species, as the type is *aethiopica*, Thunb., which is not congeneric with them. There appears to be no valid reason for separating such species as *chrysophila* and *brevipalpis* from *Buplex*, Austen (1920).

Lilaea must be dropped from the Australian list; the type is *lurida* (= *Silvius luridus*) as designated by Coquillett (1910) and not *roei*, as designated by Enderlein.

It is curious that the character given by Enderlein for separating *Lilaea* is "r 4 ohne aderstümme 1," whereas Walker gave as one of the differential characters, the presence of an appendix to this vein.

The remaining genera include those species placed by the older writers in the genera *Erephopsis*, *Diatomineura* and *Apocampta*.

In my previous paper I suggested that all the Australian species of this group, with the exception of *Apocampta subcana*, should be included in the one genus—*Oscia*. I have re-examined all the Australian species available with a view to ascertaining whether they were divisible into genera and particularly in order to determine the value of the characters suggested by Enderlein.

The relative lengths of the proboscis and palpi have been extensively used by Enderlein. In the table of the subfamily MELPIINAE the genera *Oscia* and *Scaptia* are thus separated.

- | | | | | | |
|---|-----|-----|-----|-----|----|
| 11. Palpus länger als die Hälfte des Rüssels | ... | ... | ... | ... | 12 |
| Palpus so lang oder kürzer als die Hälfte des Rüssels | ... | ... | ... | ... | 13 |
- Oscia* falls under 12 and *Scaptia* in the division commencing with 13.

In the table to the genera of the subfamily PANGONIINAE, tribe PANGONIINI, similar characters are used for separating *Erephopsis* and *Plinthina*.

- | | | | | | | | | | |
|--|-----|-----|-----|-----|-----|-----|-----|-----|----|
| 13. Palpus länger als die Hälfte des Rüssels. Rüssel dick, Länge etwa von Kopfhöhe oder kürzer | ... | ... | ... | ... | ... | ... | ... | ... | 14 |
| Palpus kürzer als der Hälfte des Rüssels. Rüssel dünn, länger als die Kopfhöhe | ... | ... | ... | ... | ... | ... | ... | ... | 15 |

Erephopsis and *Plinthina* are included under 14 and 15 respectively, the genotypes designated being *guttata*, Don., and *macroporum*, Macq.

In regard to Australian genera it would appear that a better division in the MELPIINAE would have been—palps as long as the shaft of the proboscis, and palps considerably shorter than the shaft of the proboscis. At first sight indeed it would appear as if the Australian species would fall into two natural groups on the relative lengths of the palps and proboscis in the female. On further examination, however, the variation that occurs in the shape of the palpi and in the length of the proboscis renders the separation along these lines more difficult. It is proposed therefore to review the whole of the species available in the light of these characters.

In the previous paper a figure was given of the head of *Oscia limbithorax*, Macq., which is stated by Austen to be congeneric with the genotype of *Oscia*. In this it will be noted that the palp is long, pointed and but little widened at the base, the length is indeed not so apparent, owing to the position in which the palp was lying in this particular specimen, but it is approximately equal in length to the shaft of the proboscis. The proboscis is short, being approximately equal to the head height. No other species has a palp quite identical in shape, but a close approach is seen in *guttata* (fig. 1), in which the palps are somewhat more widened at the base of the second joint. In this species also the proboscis is short and thick. Agreeing with *guttata* are two other species, *singularis*, Macq. (= *submacula*, Walk.) and *media*, Walker, both large robust species, very similar in appearance to *guttata*; a similar structure also occurs in *aurcovestita*, Ferg. & Henry. The question of the relation of these species will be discussed more fully later in this paper.

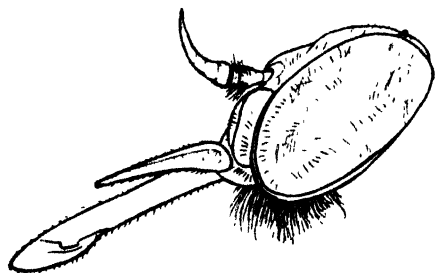


Fig. 1. *Scaptia guttata*, Don., head, $\times 5.3$.

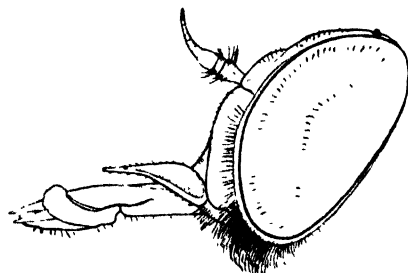


Fig. 2. *Scaptia aurata*, Macq., head, $\times 9.3$.

In *aurata*, Macq., the genotype of *Scaptia*, Walker, the palps are again approximately as long as the shaft of the proboscis and the latter is short, but the palps are more decidedly widened at the base (fig. 2). The following species have palpi of this character combined with a short proboscis—*aurata*, Macq., *auriflua*, Don., and probably *plana*, Walk., *patula*, Walk., and *ianihina*, White. Closely allied to these last is the group of which *brevirostris* (fig. 3) may be taken as the type; this group, which is distinguished from the last mainly by the clothing, includes *brevirostris*, Macq., *fulgida*, Ferg. & Henry, *testacea*, Macq., *montana*, Ric., *abdominalis*, Ric., and *jacksoniensis*, Macq. The exact shape and the length varies in the different species and in some, e.g., *jacksoniensis*, the shape approaches closely to that of *guttata*. In *pulchra*, which appears to belong to the same group, the palpi are slightly shorter than the shaft and may in individual specimens be quite short.

In all these species the proboscis is approximately as long as or but little longer than the head-height. There are other species in which the proboscis is short; these will be considered later.

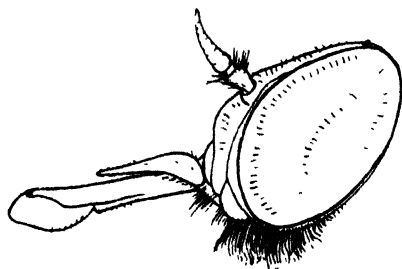


Fig. 3. *Scaptia brevirostris*, Macq., head, $\times 9.3$.

Opposed to the species with short proboscis and long palpi are various species, previously mainly included in *Erephopsis*, in which the proboscis is at least $1\frac{1}{2}$ times the head-height and the palpi short both actually and relatively. *Erephopsis aureohirta*, Ric. (fig. 4) may be taken as an example of this type of structure.

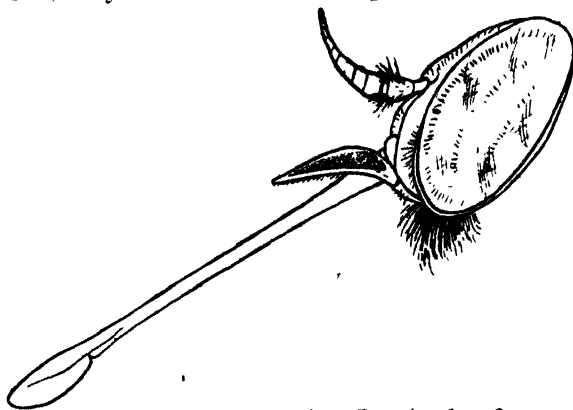


Fig. 4. *Scaptia aureohirta*, Ric., head, $\times 6$.

Closely allied to this species are *quadrimacula*, Walk., *lasiophthalma*, Macq. (= *contigua*, Walk.) and *concolor*, Walk. In these the palps are moderately broad, obtusely pointed and with a shallow lateral excavation.

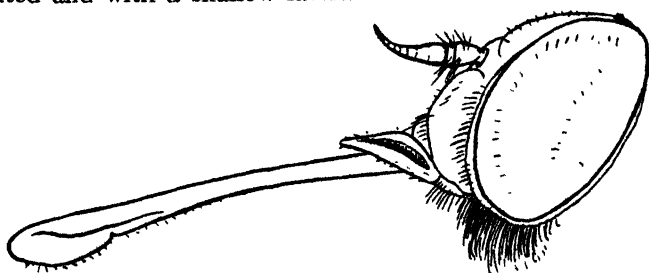


Fig. 5. *Scaptia maculiventris*, Westw., head, $\times 9.3$.

These species are connected with a group which includes *subcontigua*, Ferg., *rufoniger*, Ferg., *maculiventris*, Westw., *georgi*, Tayl., *guttipennis*, Ferg., *clavata*, Macq., and *auripleura*, Tayl. In these the palpi are more deeply grooved and generally narrower (fig. 5). A connecting species between the last two groups is *xanthopilis*,

Ferg. & Henry, in which some individuals have the outer surface of the palps more deeply grooved than others.

Erephopsis gemina is allied to the last group, in the narrower palpi, but the groove is quite shallow. A somewhat similar type is seen in *subappendiculata*, Macq. (= *inflata*, Ric.). In *regis-georgei*, Tayl. (fig. 6) a somewhat different shape is seen; this occurs also in *neotricolor*, Tayl., and in an undescribed species from New South Wales which in other respects is practically inseparable from *gemina*.

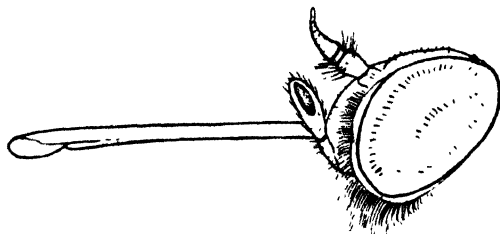


Fig. 6. *Scaptia regis-georgei*, Taylor, head, $\times 10$.

It is to be understood that the individual species in all these groups show slight differences in shape and length, while corresponding to a general type.

A more outstanding type of palp is to be seen in *vicina*, Taylor (fig. 7).

If these were all the species to be considered it would be easy to divide them into two genera, one with short proboscis and long palpi and the other with long proboscis and short palpi.

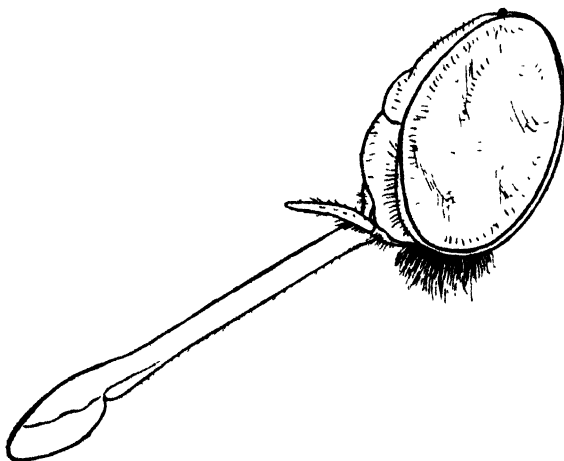


Fig. 7. *Scaptia vicina*, Taylor, head, $\times 9.3$.

There exist, however, various species in which the combination of short proboscis and short palpi occurs. These also fall into more or less well defined groups. In *violacea*, Macq. (fig. 8), the palpi are short and flat, and more or less leaf-like. A similar structure occurs in *bancrofti*, Austen, and in *gibbula*, Walk. This type might almost be regarded as an approach to the type seen in *brevirostris*, but without the extension. A further link in this direction is perhaps shown by *tricolor*, Walk., which has somewhat more elongate palpi, though shorter than half the length of the shaft.

A more puzzling case is *ruficornis*, Macq. (= *constans*, Walk.), which has a palp simulating that of *brevirostris* in shape, though much shorter, and in some individuals the palpi are without the extension (fig. 9).



Fig. 8. *Scaptia violacea*, Macq., head, $\times 10$. Fig. 9. *Scaptia ruficornis*, Macq., head, $\times 8.6$.

A somewhat different type is shown by the *Plinthina* group of which *binotata*, Latr. (= *macroporum*, Walk.) is the genotype. In these the proboscis is short, and the palpi are short, comparatively broad, without a long extension and rather deeply excavate. This group includes, *binotata*, Latr., *cinerea*, Ric. (fig. 11), *divisa*, Walk., and *clelandi*, Ferg.

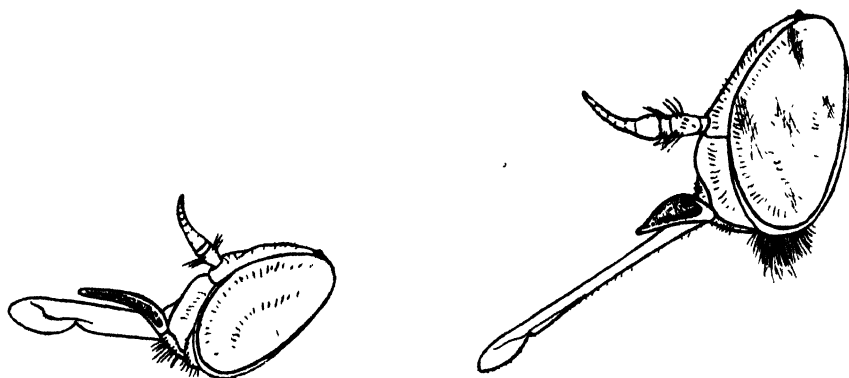


Fig. 10. *Scaptia subcana*, Walk., $\times 10$.

Fig. 11. *Scaptia cinerea*, Ric., head, $\times 8$.

From this review it would appear that several courses are open to the systematist.

(1). To include all forms under the one genus. In this case the name of the genus might be either *Oscia* or *Scaptia*. The former is in general use already, but the latter has page priority. The fact emphasised in my previous paper that *Oscia* had been already selected by Brèthes to replace *Diatomineura* loses its significance, since Coquillett had previously fixed the genotype to which the generic name should apply. As *Scaptia* has page priority and is founded on an Australian genotype, I propose to use the name for Australian species.

(2). To separate the species on the comparative lengths of palpi and proboscis. In this case species with palpi as long or nearly as long as the shaft of the proboscis would be included under *Scaptia*, and species with palpi shorter than the proboscis would form a distinct group.

(3). To form a number of genera including the different types of palpi outlined in the preceding pages. I do not think that this course is permissible, as there are intergrading species between most of the groups.

The most distinct would appear to be that to which Walker gave the name *Plinthina*. It is, however, apparent from his tables that Enderlein would include under this name most if not all of the species with long proboscis and short palpi in which R_5 is closed.

The group, including the genotype of *Plinthina*, is distinguished by a relatively short proboscis, short broad palpi, rather deeply excavate, cell R_5 closed remote from the wing margin, the presence of a large distinct stigma, and the coloration of the wings. None of these characters, with the exception of the wing coloration, is absolutely peculiar to the group, and the dark centre to the cells varies considerably and is almost evanescent in *P. divisa*, Walk. The conspicuous stigma is present in *violacea*, while the palpi are not unlike those of several other species, and show rather considerable differences in shape *inter se*. There seems, therefore, little objection to the use of the name *Plinthina* to include all forms with short palpi, irrespective of whether the proboscis is long or short. I would therefore suggest adopting this course, but in as much as this review is based solely on Australian material, it would be advisable to wait until extra-limital, and particularly South American, species can be examined. This cannot be done in Australia, and the classification must therefore be left in abeyance. The notes are, however, offered in the hope that they may be of use to entomologists in other countries who may be interested in the classification of the group. In the meantime it is proposed to use the name *Scaptia* for the whole group, employing *Plinthina* in a subgeneric sense.

It will be noted that the closure or otherwise of cell R_5 has been almost completely disregarded, but the majority of species with R_5 open will fall into *Scaptia* (*sens. strict.*) and those with R_5 closed into *Plinthina*, though there are numerous exceptions to each rule.

It should perhaps be mentioned that the foregoing arguments are based on the female sex alone. In the male of all the species examined the palpi are short, with a round first joint and a subcylindrical second joint, which is generally slightly curved and flattened subapically on the outer surface. The general conformity to one type of palpal structure in the male is an additional argument for placing all the forms under one genus irrespective of the variation in the female sex.

Several further names, however, remain to be considered; these are *Triclista*, *Apocampta*, *Palimmecomyia* and *Parasilvius*.

Triclista is proposed for *limbinevris*, Macq., and is placed in the tribe SCIONINI, distinguished by the cell M_3 being closed. Now *limbinevris* is placed by Ricardo as a synonym of *media*, Walk., in which this cell is open, and it is described as open in Macquart's description. Furthermore, *media* is closely allied to *guttata*, Don., already included in the *Oscia* complex. It is certainly the case that in *guttata* M_3 may exceptionally be closed, and in the third species of this group, *singularis*, Macq. (= *submacula*, Walk.), this is invariably the case. I do not think, however, that these three species can be dissociated, nor do I think they can be separated from *Scaptia* despite their large size and robust appearance.

Apocampta. This genus is maintained as distinct on somewhat trivial characters; Miss Ricardo gives in her key to the Pangonine genera "Wings short; body flat and elliptical", but the wings are not relatively short for the size of the insect. Moreover, Miss Ricardo, though she separated *Apocampta* from *Diatomineura*, described the unique species over again under the name of *D. minima*.

Enderlein separates it on the character of the second antennal joint ("2. Fühlerglied oben spitz ausgezogen"), apparently following Schiner, who described the second joint as ending in a bristle. Miss Ricardo has already shown that this is not the case, and the structure of this joint does not differ from that found in other species of the group. There is indeed practically nothing to separate *Apocampta* from *Scaptia*, beyond a slight difference in the shape of the palpi (fig. 10). The recent acquisition

of an undescribed species from Western Australia with palpi similar to *Apocampita subcana* has induced me definitely to sink the genus under *Scaptia*.

Palimmeomyia. In the structure of the palpi and in the relatively long proboscis this genus might be referred to the second section of *Scaptia* as defined above, but the species are of a very different appearance, with a different texture and a colour distribution not found elsewhere among Australian species of TABANIDAE. The face also is somewhat more protuberant, and the first antennal joint is longer than is usual in the genus *Scaptia* (fig. 12).

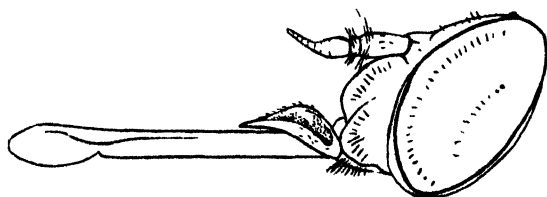


Fig. 12. *Palimmeomyia walkeri*, Newm., head, $\times 8.6$.

Parasilvius. In the original description it was stated that the third joint of the antennae might be regarded as 5-annulate or 8-annulate; 5 annuli are distinct and 3 are indistinct in the female and there are only 5 annuli, all distinct, in the male. The shape of the base of the third joint is different from that in *Scaptia*, and the palpi are short with 2nd joint sub-cylindrical and alike in both sexes, which is not the case in *Scaptia*. Moreover, the shape of the front is more like that found in *Ectenopsis*.

The other Pangoniine genera on the Australian list are *Pelecorrhynchus*,* *Ectenopsis*, *Demoplatus*, *Cryptoplectria*, *Coenoprosopon*, *Phibalomyia*, *Pseudotabanus*, *Pseudopangonia*, *Silvius*, *Mesomyia* and *Chrysops*.

Ectenopsis, Macq. It is evident that this genus is unknown to Enderlein, who, moreover, can hardly have been familiar with Miss Ricardo's re-description of it. Enderlein includes it in his subfamily SILVIINAE, distinguished by the 5-annulate third antennal joint, whereas the genus belongs to the 8-annulate group.

Demoplatus and *Cryptoplectria*. Enderlein omits *Demoplatus* from his first paper but erects a new genus *Cryptoplectria* for *D. australis*, Ric., in his second paper, on the presence of small spurs to the intermediate and hind tibiae. These spurs are, however, also present, though smaller, in the type species, *Demoplatus trichocerus*, and indeed the two species are closely allied. I cannot therefore regard *Cryptoplectria* as a valid genus.

I have also grave doubts of the distinctions of *Coenoprosopon* from *Demoplatus*. In the females of the species of *Demoplatus* in which this sex is known, the structure closely approaches that of *Coenoprosopon wainwrighti*, Ric., known only from females, and it is not impossible that this species may prove to be the unknown female of *Demoplatus australis*, or of an allied species. *Coenoprosopon* has page priority over *Demoplatus*.

Phibalomyia, Tayl., is a very distinct genus, allied to *Buplex* but with an angularly protuberant face.

Pseudopangonia is also a very distinct genus, allied more to the *Ectenopsis* group than to the *Scaptia* or *Buplex* complexes. The antennae are thin, as in *Ectenopsis*, but have only 4 visible annulations.

* *Pelecorrhynchus*, Macquart, is a well-marked genus not to be confused with any other in Australia. Whether the separation of the South American species under the genus *Cosnura*, Bigot, 1857, is valid must remain for others to settle.

Pseudotabanus on the other hand shows a decided approach to *Silvius* and indeed is very doubtfully distinct from that genus. The basal annulations of the 3rd antennal joint are very indistinct and not always traceable, while in other respects the species do not appear generically separable from such species as *S. montanus*, *S. angusticallosus* and *S. niger*.

Some of these latter species have been placed in *Mesomyia* on account of having more or less distinctly pubescent eyes; without further knowledge of the genotype of *Mesomyia* I do not feel disposed to admit this genus to the Australian list on this character alone.

The Australian species of *Silvius* fall into several groups, some of which in the future may be found to require generic separation, but I do not think that this is advisable at present.

If *Pseudotabanus* is to be sunk under *Silvius* some rectification of names will be necessary, as *Pseudotabanus distinctus*, Ric., will clash with *Silvius distinctus*, Tayl.

Chrysops. Two species of this genus occur in Australia, both are limited to North Queensland, and the record of Tasmania given by Macquart for *C. testaceus*, Macq., appears certainly erroneous.

In Enderlein's division *Opistanoplae* occur six genera which have been recorded from Australia. In the subfamily TABANINAE, the genera *Stibasoma*, *Tabanus*, *Therioplectes* and *Ommia*; in the subfamily DIACHLORINAE, the genus *Paracanthocera*; and in the subfamily HAEMATOPOTINAE, the genus *Dasybasis*. To these should be added *Cydistomyia*, Tayl. (unknown to Enderlein), while *Holcopsis*, Enderl., described in a later paper, is said to be doubtfully from Australia and is at present little better than a *nomen nudum*.

Paracanthocera, described in the same paper for *Acanthocera australis*, Ric., will probably prove valid, but it is doubtful if the species is actually known to Enderlein.

Stibasoma is doubtfully Australian, the species *S. hemiptera*, Surc., will probably be found to have been wrongly labelled as from Australia.

Dasybasis, Macq., appears to owe its origin to a mistake in counting the annulations of the third antennal joint. The opinion has already been expressed that the genus should be sunk under *Tabanus* subgenus *Therioplectes*.

Cydistomyia is also very doubtfully distinct from *Tabanus*. From an examination of the antennae in the type I am of opinion that only 5 annulations exist—not 6 as stated by Taylor. Although unlike other Australian species in general habitus, it conforms well with some extra-limital species, such as *T. sharpei*, though there are of course specific differences. If the genus be suppressed it will be necessary to re-name the species, as *Tabanus doddi*, Tayl., is already in use.

Ommia, End., with genotype *O. prisca*, End., is little better than a *nomen nudum*. What the species may be it is difficult to say, as no Tabanine species with ocelli present has so far been described from Australia. If the species is really Australian and really Tabanine it must be a most unusual type. The elimination of these names leaves the bulk of the Australian species under *Tabanus* and its subgenus *Therioplectes*.

Enderlein treats the latter as a distinct genus, but it seems more rational at present to regard the species included in *Therioplectes* as only subgenerically distinct. It is possible that some of them might be included by Enderlein in other of the genera given in his tables, many of which appear to be distinguished by characters which seem very doubtfully of generic value.

I am indebted to Mr. D. J. Farrell for the accompanying illustrations. These are free-hand drawings, and have been made as exact as possible and the measurements carefully checked; the antennae are, however, somewhat diagrammatic.

Appended is a list of the genera I recognise as occurring in Australia, with the names relegated to synonymy. A query mark indicates that the status of a name is doubtful. The names in synonymy must also be understood to be applied to Australian species only; in certain cases these names have valid status in other faunal regions.

Subfamily PANGONIINAE.

Pelecorrhynchus, Macquart.

Scaptia, Walker.

Pangonia, auct.

Clanis, Walker (*nom. praeocc.*).

Oscia, Walker.

Plinthina, Walker.

Diatomineura, Rondani.

Erephopsis, auct.

Trichista, Enderlein.

Apocampta, Schiner.

Phibalomyia, Taylor.

Elaphromyia, Taylor (*nom. praeocc.*).

Palimmecomyia, Taylor.

Buplex, Austen.

Corizoneura, auct.

? **Copidapha**, Enderlein.

Parasilvius, Ferguson.

Ectenopsis, Macquart.

Corizoneura, Enderlein (*nec* Rondani).

Coenoprosopon, Ricardo.

Demoplatus, Ricardo.

Cryptoplectria, Enderlein.

Pseudopangonia, Ricardo.

Silvius, Meigen.

? *Pseudotabanus*, Ricardo.

Mesomyia, auct.

Lilaea, Walker.

Chrysops, Meigen.

Subfamily TABANINAE.

Tabanus, Linnaeus.

? *Cydistomyia*, Taylor.

Atylotus, auct.

Therioplectes, Zeller.

Dasybasis, Macquart.

- ? *Stibasoma*, Schiner.
Paracanthocera, Enderlein.
 ? *Ommia*, Enderlein.
 ? *Holcopsis*, Enderlein.

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Addendum.

Since the foregoing paper was sent for publication the text of Enderlein's paper "Studien an blutsaugenden Insekten, I. Grundlagen eines neuen Systems der Tabaniden" (Mitt. Zool. Mus. Berlin, xi, Feb. 1925) has become available in Sydney. While regretting that I had not seen this important publication before my paper was written, it does not appear that the criticism therein levelled against Enderlein's preliminary tabulation requires to be modified. The publication, however, by its fuller description enables one to arrive more certainly at the species upon which Enderlein's new classification is based. This is the case where new genera were proposed with a new species as genotype. In other ways the citation of species under the different genera has also been helpful. The following notes are to be regarded as supplemental to the remarks made in the body of the paper.

Pelecorhynchus. I am unable to understand Enderlein's statement in his description of the genus, "Augen . . . beim ♂ in 2 Teile scharf linig geschieden, der obere mit grossen, der kleinere untere mit keinen [?] kleinen] Ommatidien." This is quite incorrect, as the eye-facets are not of two kinds. Enderlein also quotes this in his table as a distinguishing character between *Pelecorhynchus* and *Coenura*.

Apocampta. It seems clear that Enderlein placed this genus from the description. He remarks that the various authors do not mention whether the eyes are bare or hairy—an admission that the genus was unknown to him.

Copidapha bifasciata. From the description given there can be no doubt that this species is the same as that previously described by Ricardo as *Corizoneura conspicua*. There is a pair in the Macleay Museum, Sydney, from the same locality (Endeavour River) as Enderlein's type. The species is anomalous in that while the eyes are densely pubescent in the male, they are practically bare in the female, a few sparse hairs only being discoverable. In other respects the species appears closely allied to *aureohirta*, *lasiophthalma*, etc., species which I have referred to *Scaptia*. *Pseudopangonia* is placed near *Corizoneura* (= *Buplex*), whereas I regard it as doubtfully distinct from *Silvius*. *Corizoneura*, as understood by Enderlein, contains mainly species which would be included in *Buplex*. The species, however, that he cites as genotype is *angusta*, Macq., which belongs to *Ectenopsis*. It is to be noted that in the list of species he proposes the name *bigoti* to replace *angusta*, Big. 1892, whereas Ricardo has already referred both *angusta*, Big., and *angusta*, Macq., to *Ectenopsis vulpecula*, Wied. 1828, as synonyms; while I have expressed some doubt on their specific identity with *vulpecula*, there can be no question that both names *angusta* refer to but one form. A number of other synonyms occur in the list of Australian species which have been sunk either by Ricardo or myself.

Coenoproson, which I regard as congeneric with *Demoplatus*, is separated from the latter by the absence of an appendix to R_4 . This is incorrect, a small or rudimentary appendix being present in both. I have already gone into the reasons which have led me to regard the opening or closure of R_5 as not being of generic character and in the main body of the paper have discussed at length the grouping of the species. It is, however, of some interest to see which species are listed by Enderlein under the different genera.

In *Scaptia* are placed 30 Australian species. Of these, nine names must be eliminated as synonyms: the remainder are mainly members of the *aurata* and *brevicornis* groups, with a few additions, such as *auripleura*, Tayl., *regis-georgei*, Tayl., *subappendiculata*, Macq., and *violacea*, Macq., which differ distinctly from the others in the palpal structure. *Erephopsis* of Enderlein contains only one species—*guttata*, Don. *Plinthina* likewise contains only *P. macporum*, Macq.

Lilaea shares with *Scaptia* the bulk of the Australian hairy-eyed species, 20 names, exclusive of New Zealand forms, being listed, 7 being synonyms, though not necessarily of others included. The majority of species belong to the section with short palpi and include both species with proboscis longer than the head, e.g., *aureohirta*, etc., and species with proboscis approximately as long as the head, e.g., *gibbula*. The group is, therefore, equivalent to the second section of *Scaptia*, which I suggest might be subgenerically separated. The name *Lilaea* is, however, not admissible, for reasons given previously. In this connection it might be noted that in all probability the *roei* of Walker was not the *roei* described in King's Survey. The identity of the latter is uncertain, but it was probably either *conspicua*, Ric. (as suggested by that author), or a similar species. Such a species would not fall into Walker's concept of *Lilaea*, but into *Clanis*. In the Melbourne Museum there is a specimen of *Buplex brevipalpis* (= *fulva*) which is labelled in Walker's handwriting as *roei*.

If the group is separated from *Scaptia* there seems to be no valid reason why *Plinthina* should not be used. Enderlein separates *Plinthina* from *Lilaea* on the presence of an appendix to R_4 in the former. I do not regard this as a satisfactory character. Enderlein also suggests that *Lilaea* might be further subdivided, and proposes, without description, the name *Astyphia* for the group to which *jacksoni*, Macq., belongs, this species being given as the genotype. This separation does not appear to be justifiable, but the name *Astyphia* may be available if *Plinthina* is not accepted.

Enderlein has evidently misidentified *Pangonia limbinervis*, Macq., the species so named which he has made the genotype of *Triclista* being undoubtedly *singularis*, as acknowledged by him; but *singularis* is certainly specifically distinct from *limbinervis*, and I believe is identical with *submacula*, Walk., which is included by Enderlein under *Lilaea*.

Dasyapha is proposed for a Chilean species belonging to his tribe SILVIINI; the validity of this genus I do not propose to discuss, and only allude to it here because at the end Enderlein states that *edentulus*, Macq. 1845, from Tasmania should belong to it and not to *Tabanus*. I do not know his authority, but am convinced that *edentulus* is certainly not a Silviine.

Mesomyia does not include any Australian species. It is rather interesting to note that the Australian insect placed in it by Surcouf (*Silvius niger*, Ric.) is referred to *Veprius*.

Silvius is held to include such species as *alcocki*, Summers, *australis*, Ric., *doddi*, Ric., *indistinctus*, Ric., etc., eight species in all being mentioned.

Veprius, Rond. 1863, is separated from *Silvius* by Enderlein practically only on the absence of an appendix to R_4 . Though the type is Chilean he places *niger*, Ric. 1917, in the genus, and also proposes a new species *V. sexguttatus*, which is I think identical with *S. fuscipennis*, Ric. 1917. I see no reason for retaining the genus in the Australian fauna.

Ectenopsis is placed near *Silvius*. I have already commented upon this; it does not appear from the notes that Enderlein was familiar with either genus or species.

Pseudopangonia is placed in the SILVINI apparently on the description.

Ommia, a genus placed in the tribe LEPISELAGINI of the subfamily TABANINAE, is proposed for the reception of a new species, *O. prisca*, from Melbourne, Victoria. The description reads extraordinarily like *Ectenopsis victoriensis*, Ing., but this species has certainly the tibial spurs present; the eyes are thinly pubescent, though wrongly described as bare in the original description, and there is a distinct appendix to R_4 . In view of these discrepancies I can only conclude that I have not seen *O. prisca*.

The genera proposed by Enderlein as members of his tribe TABANINI require close examination, since he appears to have been somewhat reckless in the making of new genera. In the table of the tribe there appear first some four genera which are separated by the presence of ocelli. Following these are three others which have at least the anterior tibiae thickened; these may be excluded from this survey since no Australian species are included. The table is then divided into genera containing bare-eyed species, and genera containing hairy-eyed species. In the first group appear three of the older extra-Australian genera, in which the antennae are situated on a prominent tubercle or swelling. The genera that interest us in the following groups are those coming under the caption "3. Fühlerglied mit scharfem Zahn oder scharfer Ecke." These genera are further separated as follows:—

15.	R_4 ohne Aderstummel	...	...	...	...	...	...	16
	R_4 mit Aderstummel	...	...	...	...	...	...	<i>Stenotabanus</i>
16.	Augen des ♂ normal	...	...	...	...	...	...	<i>Tabanus</i>
	Augen des ♂ in 2 Teile scharf linig geschieden	...	...	...	...	...	...	<i>Straba</i>

Under *Stenotabanus* are included several Australian species, *germanicus*, *neo-germanicus*, *posticus* and *antecedens*. The last-named species is certainly out of place here, as the eyes are distinctly hairy. Whether the presence or absence of an appendix to R_4 is a valid reason for separating the genus is open to question. The use of a sexual character, like that of the presence or absence of two types of facets on the eyes of the male, is also highly debatable, and open to the objection that it is impossible to place species in which, as so often happens, the female alone is known. I have examined all the species of which specimens are available in the Departmental Collection. This includes 58 out of 73 described species with bare eyes; in other cases the necessary information has been obtained from the descriptions. In 24 species an appendix is present; in at least two this appears to be variable; these two are, however, related to species in which the appendix is present. As regards the eyes, males of only 12 species are available for examination; in 9 the eyes are divided into an upper large-faceted area and a lower small-faceted area; in 5 out of the 9 the appendix is present; in 3 cases the eyes are simple and there is no appendix. It may be possible to separate the species into groups on these lines, but with only one sex available in the majority of cases, judgment will require to be suspended. In the section with hairy or pubescent eyes no less than 15 genera are proposed, separated on such characters as the presence or absence of the ocellary tubercle (ocelli themselves being absent), the presence or absence of an appendix to R_4 , the separation of the eyes of the male into two parts, etc. It has been the custom to group all the hairy-eyed species under *Therioptectes*, regarding the latter as only subgenerically distinct from *Tabanus*. Used in this sense *Therioptectes* includes *Atylotus*, which is of later date. The remaining names were not proposed by Enderlein either in 1922 or in 1923.

While the above would appear to be the rational course to pursue it is necessary to examine the Australian species further in the light of the characters given by Enderlein. From a survey of the species in the Departmental Collection, which includes the vast majority of described Australian species, it appears that the ocellary triangle

is absent, or is only traceable with difficulty, that with two exceptions the appendix to R_4 is present, and that in all the males known the eyes possess two types of facets. According to Enderlein's key, these species would fall into *Dasystypia*, and under this genus Enderlein includes the Australian species *exulans*, *gregarius* and *gentilis*, of which only the last-named is known to me.

The two remaining species, *microdonta*, Macq., and *wynyardensis*, Hardy, would fall into *Atylotus*, a holarctic genus according to Enderlein.

The New Zealand species have been for the most part referred to the genus *Sziladya*, which is separated from *Atylotus* on the eyes in the male being normal. Under the same genus *avidus*, Bigot, is placed, obviously in error, as the eyes are bare in this Australian species.

While the Australian species would then appear to constitute a fairly compact group, it is necessary to consider how those characters hold with species from other regions. With such trivial characters it is highly important that they should be correlated with geographical distribution. It must be remembered that the appendix to R_4 is the rudiment of the intraradial cross-vein and, as a rudiment, may be expected to appear in species in remote parts of the world without necessarily indicating close generic relationship. Furthermore, within the one species this appendix may vary considerably in length, even to complete disappearance. As regards the eyes of the male it should be mentioned that the area covered by the larger facets varies in different species, and also the facets vary greatly in size. There are several Australian species amongst the division with bare eyes which can hardly be separated from species with hairy eyes, and in some of these a few sparse hairs can be seen with high power examination. While, therefore, preserving an open mind as to the correct generic description of the Australian species, I think it advisable for the present and for the avoidance of confusion to refer them as before to *Tabanus* and its subgenus *Theriopectes*.

Holcopsis is erected for the species *H. fenestrata*, End., of which a description is given. I can only say that I know of no species to which the description can apply and doubt the assumption that it is from S.W. Australia. Enderlein admits that the country of origin of his unique specimen is uncertain.

No further comment is required upon the genera *Paracanthocera* and *Dasybasis*. The genera *Cydistomyia*, *Phibalomyia* and *Palimmecomomyia* were unknown to Enderlein, and he was unable from the described characters to place them in his system; no mention is made of *Parasilvius*.

It seems that Enderlein must have been ignorant of much of the work of recent years on Australian TABANIDAE. Several species described by Ferguson & Henry in 1920 are misquoted as of Ferguson & Hill, while only the first of the two papers of these authors is mentioned. Two other papers by myself appear to have been overlooked; while no attention is paid to synonymy published by Ricardo, as well as by Ferguson & Hill.

CONCERNING THE NOMENCLATURE AND SYNONYMY OF CERTAIN ORIENTAL AND EAST AFRICAN BLOODSUCKING MUSCIDS (DIPTERA).

By Major E. E. AUSTEN, D.S.O.

In his recently published paper "Diptera of Medical and Veterinary Importance, I.—Types of Older Authors in Continental Museums" (Philippine Journ. Sci., xxvii, 2, pp. 177–200, June 1925), Major W. S. Patton (*loc. cit.*, p. 189), writing of *Haematobia nudinervis*, Stein (Ann. Mus. Nat. Hung., xvi, 1, p. 150, 30 August 1918), states that this is the species hitherto known as *Bdellolarynx sanguinolentus*, Austen; and that, since "*nudinervis* was described a year before *sanguinolentus*," Stein's name for "this common Oriental bloodsucking muscid . . ." must henceforth be adopted. On the question of priority, however, Major Patton is in error. The description of *Bdellolarynx sanguinolentus* (Ann. Mag. Nat. Hist. (8), iii, p. 290) appeared in March 1909—nine and a half years earlier than that of *Haematobia nudinervis*, so that the latter designation is antedated by a fairly wide margin.

According to Patton (*loc. cit.*), *Haematobia rufipes*, Stein (*l. cit.*, p. 151), the types of which, like those of *H. nudinervis*, were obtained in Formosa, is likewise identical with *Bd. sanguinolentus*, Austen.

In Patton's opinion "the characters used to define the genus *Bdellolarynx* [Austen, Ann. Mag. Nat. Hist., *loc. cit.*] are not of generic value," so that the name *Bdellolarynx* becomes a synonym of *Haematobia*, Rob.-Desv. The present writer, however, having examined the types of *Bd. sanguinolentus* (the genotype of *Bdellolarynx*) afresh, and compared them with specimens of two species of *Haematobia*, sees no reason to reverse the conclusions as to the generic distinctness of *Bdellolarynx* formed by him in 1909.

While in Berlin, in 1922, Major Patton saw a number of cotypes of the East African *Glossinella schillingsi*, Grünb. (Zool. Anz., xxx, p. 86, 1906), and now writes (*loc. cit.*) that, in spite of the bad state of preservation of the specimens, he has "no doubt that *schillingsi* is a species of *Lyperosia* and is in all probability *L. minuta*." The identity of *Glossinella*, Grünb., with *Lyperosia*, Rond., was pointed out by the writer so long ago as 1909 (*cf.* Austen, "Illustrations of African Blood-sucking Flies," p. 136, note), this synonymy being based on an examination of the entire series of cotypes of *Glossinella schillingsi*, which were courteously forwarded for that purpose to the British Museum (Natural History) by the authorities of the Zoological Museum, Berlin. But since in the female of *L. schillingsi* the eyes are much wider apart than in the corresponding sex of both *L. exigua*, de Meij., and *L. minuta*, Bezzi, it would scarcely seem that the subject of Patton's note can be identical with either of these species.

A NOTE ON THE REARING OF ANOPHELINE LARVAE.*

By MARK F. BOYD, M.D.

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Most field entomologists studying Anophelines limit their collections of Anopheline larvae to those in the third and fourth instar, owing to the lack of success commonly encountered in rearing those in the earlier stages, and regard the rearing of adults from ova as more or less of a "stunt," success being so rare.

Extreme drought recently made Anophelines so scarce that we were confronted by a distinct problem in order to compensate for the scarcity of field material. We have now discovered practical means for the rapid rearing of first and second instar larvae found in the field, or of rearing adults from ova deposited by captive females, and owing to the high degree of success attained feel the method may prove of service to others.

Most entomologists are accustomed to feed their Anopheline cultures on some blue-green algae, usually *Spirogyra*, or on comminuted insects. We have found that a small amount of Fleishman's yeast serves as an ideal food when daily rubbed into the superficial layer of water in the culture pan, and that the larvae grow at a remarkable rate and produce very vigorous adults. The rapidity is indicated by an experiment in which a culture of first instar larvae developing from a batch of ova deposited in the laboratory were when 3 days old divided into two batches, one of which was fed solely on *Spirogyra*, and the other solely on yeast. One month later of the three survivors of the *Spirogyra* culture, only one had attained the fourth instar, while within 9 to 13 days all of the larvae fed on yeast had pupated and emerged after 36 hours in the pupal stage, none having died.

We have kept marble dust in the culture pans to conserve the alkalinity of the water, and find that if the water is not in circulation, it must be changed each 2 or 3 days to avoid its becoming foul from decomposing yeast.

The optimum temperature for larvae of *Anopheles quadrimaculatus* and *A. crucians* appears to be between 70° and 80° F. If the temperature exceeds 85° F., the mortality among the larvae will be very high. We also find it advantageous to separate the larvae of different sizes, as the small larvae do much better when kept by themselves. In order to control temperature, secure aeration, and separate the larvae, an inclined stand, each shelf of which projects beyond the one above, has been found very useful. The larvae pans are set on the shelves, each pan being equipped with a small siphon which discharges into the pan immediately below, and the lowest pan discharges into a pail. Each siphon is protected by a cylinder of screen. The siphons are adjusted to maintain a 1 to 1½ inch water level, and preferably discharge by a drip, instead of a rapid stream. The uppermost pan serves as a reservoir, in which ice water is placed and by means of a siphon starts the water through the series of pans. First and second stage larvae are kept together, while third and fourth stage are separated. Those that have moulted are transferred daily to the pans for the next higher instar, and pupae are daily collected for the emergence jars. The stand should be situated where it receives bright diffused light, but not direct sunlight.

From our experience, it would appear that the chief nutritional difficulty in rearing larvae in the laboratory has been that the usual diet was lacking in vitamins, probably of the growth stimulating type. Yeast is, in addition, a rich nitrogenous food.

* The studies and observations on which this paper is based were conducted with the support and under the auspices of the International Health Board of the Rockefeller Foundation.

ON A NEW TRICHOGRAMMATID (HYM., CHALCIDOIDEA) PARASITE
OF THE COTTON STEMBORER (*SPHENOPTERA* SP.).

By JAMES WATERSTON, B.D., D.Sc.

Genus *Lathromeris*, Först.

The antennae are eight-jointed, viz., scape, pedicel, two ring joints, and four in the club. The second ring joint is very minute, and as it lies practically within the base of the club, its presence is demonstrable only in slowly dehydrated preparations. The number of the major sensoria on the club segments is probably a generic character. In the ♀ this appears to be 1.1.2.3, and in the ♂ 1.1.1.2. The following details of chaetotaxy would also seem to be of generic value: mesoscutum with four stout bristles (one posterolaterally and one in front); one on parapside before the tegula and another on the invading portion of the axilla; scutellum four bristles; metanotum 2.2 (very minute); propodeon two (minute) behind the spiracle.

Lathromeris johnstoni, sp. n.

A very dark coloured species recognisable by: (a) the mesonotal sculpture; (b) neurulation; (c) first club segment; and (d) the mandibles.

♀, ♂. Black or blackish brown, with the following parts paler: antennae pale or slightly dusky with the following regions more definitely infuscated: (a) club (generally); (b) pedicel on basal half, especially above; (c) scape on basal half and bulla; eyes and ocelli red; face (upper half) and vertex; a faint indefinite spot on each protergite; parapsidal sutures and mid line of scutum and scutellum; on the latter also a small clearly defined spot on each side of mid line; a faint oblique streak on mesopleura (following the internal incassation) and another between mesosternum and pleura; all the knees, the tarsi, and the fore tibiae; mid and hind tibiae mainly on distal third; on the abdomen little except the sutures.

♀. Head seen from above much wider (5:4) than thorax; vertex broader (8:7) than long, occupying two-thirds of the width of the head. Orbits parallel on anterior half, slightly divergent posteriorly; ocellar triangle short and obtuse; posterior ocelli near the hind margin, about two diameters from the orbits and three to four from one another; the anterior ocellus well behind the middle of the vertex, being placed at one-third. Chaetotaxy: 20 bristles on vertex, viz., 1 behind each posterior ocellus, 1 at side, 1 in front, and 4 between the pair, a row of 5 from each side of the anterior ocellus to the orbit; one stout bristle at upper occipital corner; clypeus 4 bristles, 2-3 before the genal line, and 5-6 behind.

Antennae (fig. 1, b), length 0.24 mm., scape (4:1) about twice the pedicel (3:2) and rather over (5:8) half the club (3:1); first segment of club dorsally about twice as long as ventrally (*i.e.*, the first suture oblique), when seen in profile; besides large sensoria the club joints bear long bristles and small mushroom-like sutural sensoria; the surface is also in places raised into linear chitinized ridges, whose fine free ends project across the sutures (seen well on the first segment); these delicate prolongations do not appear to rise from pustules.

Mandibles (7:5) (fig. 2, d) tridentate, the teeth short; cutting edge above the uppermost tooth simply rounded. Maxillary palpus (about 7:2) shorter than its long terminal bristle. Labial palpus represented by a bristle (about as long as the maxillary palp) rising from a pustular base. Ligula with 4 setigerous pustules.

Thorax with the protergites triangular, raised reticulate, the cells elongate; each sclerite with three bristles in median row and five before hind edge. Mesonotum completely longitudinally striate, the pattern continuing on to the propodeon. Propodeal spiracles broadly oval, moderate in size. Mesosternopleurae with pattern hardly raised where discernible (*e.g.*, on sternum), the cells rather elongate.

Forewings (2:1) (fig. 2, *e*), length 0.42–0.45 mm.; submarginal: marginal: radius, 12:4:3. Hindwings 9–10 times as long as broad (fig. 2, *f*), length 0.38 mm.; three longitudinal rows of discal cilia; longest cilia of fringe half as long again as the wing is broad.

Forelegs, length 0.4 mm.; coxa (15:8) two-thirds of the femur (4:1) or three-fourths the tibia (16:3); femur, external surface with subdorsal and median rows of about 6 short bristles each; tibia, 6 bristles on dorsal edge, spur about one-fifth from apex; tarsus, 10:12:13. Mid-leg, length 0.45 mm.; femur (4:1) three-fourths of the tibia (7:1), which bears ventrally 7 spinose bristles and 8–9 on outer aspect, the spur being four-fifths of the first tarsal joint; tarsus about five-sixths of the tibia, joints in ratio 15:15:13. Hind leg, length 0.52 mm.; coxa (7:5) not much shorter than femur (3:1), which bears 2 ventral bristles; tibia (6:1) about one-third longer than femur, with about 20 short stiff bristles on inner aspect; tarsus, 13:15:13.

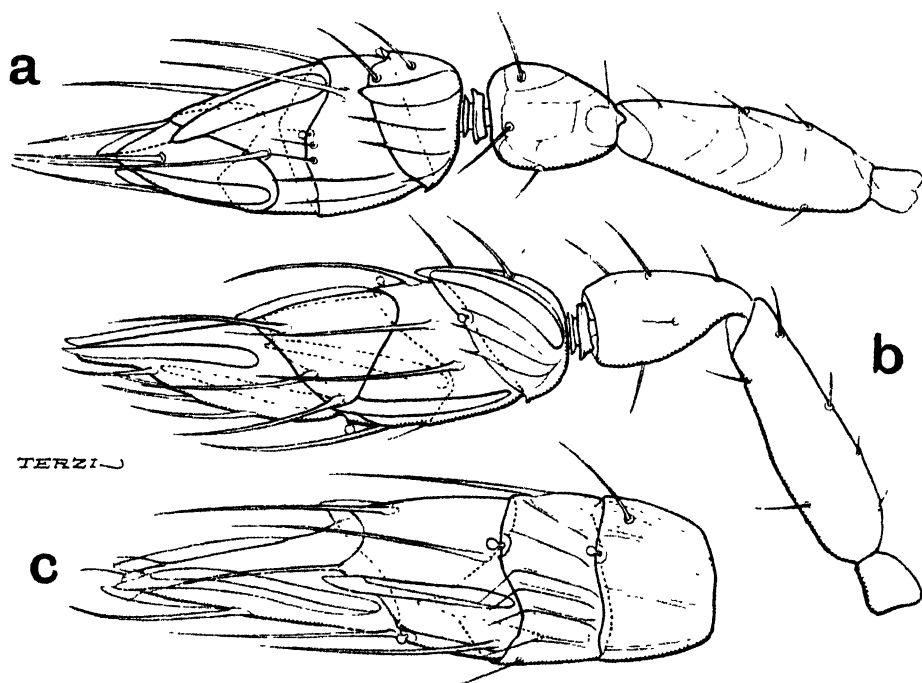


Fig. 1. *Lathromeris johnstoni*, Waterst., sp. n.: *a*, antenna of ♂; *b*, antennae of ♀. *Lathromeris scutellaris*, Forst.: *c*, club of antenna of ♀.

Abdomen smooth, except at sides on first four tergites, where the pattern is raised (elongate cells about two deep). Tergites subequal. Spiracles of the 6th (8th) tergite small circular, about half the size of those on the propodeon. Mediodorsally the abdomen is bare, without complete transverse rows of bristles till the last two segments (5th and 6th). On anterior segments the bristles are lateral: (i) 1, 1; (ii) 1–2, 1–2; (iii–iv) 2, 2; (v–vi) 4, 4; on the 6th is also an extra bristle at the inner

edge of the spiracle. Each lobe of the ovipositor sheath bears a minute apical bristle. Sternites smooth, the first four equal, with two median bristles (1 : 1), the last half as long again with the following chaetotaxy: on apical edge 4 stronger and 4 minute (quite median) bristles (2, 4, 2), and in front of these 6 bristles in two longitudinal rows.

Length, 0.6–0.65 mm.; expanse, 0.96–1.05 mm.

♂. Very similar to the ♀ in colour and proportions, but smaller. Antennal club (fig. 1, a) more globose; pedicel broader; sensoria fewer, as noted above.

Length of antennae, 0.18 mm.; forewing, 0.37 mm.; hindwing, 0.32 mm.; fore leg, 0.32 mm.; mid leg, 0.35 mm.; hind leg, 0.44 mm.

Length, 0.55 mm.; expanse, 0.88 mm.

Type ♀ in British Museum.

(One of a series (1 ♂, 7 ♀) reared from eggs of *Sphenoptera*, xii, 1923–ii, 1924.)

BRITISH SUDAN: Khartoum (*H. B. Johnston*).

The following table summarises the differences between genotype and the species just described:—

Lathromeris scutellaris, Först., ♀.

First suture on club of antenna oblique (fig. 1, c); mandible with spinose prolongation of cutting edge above the third tooth (fig. 2, b).

Forewing marginal vein about two and a-half times as long as the radius (fig. 2, a); fringe on anterior half of its apical margin broad, the cilia increasing rapidly in length, the longest being twice the radius or one-third of the breadth of the wing.

Hind wing fringe at longest twice the breadth (fig. 2, c); two rows of discal cilia, the second antemedian.

Mesonotal sculpture striate reticulate, the striae running through a fundamental pattern of large cells.

As regards colour *L. scutellaris* appears to be a much more extensively pale insect, e.g., the spot on each protergite is much larger and there are two large yellow spots on the mesopleurae.

The single example (♀) of the genotype which I have studied was taken by Dr. B. N. Blood (England, Somersetshire, Bristol, Flax Bourton, Combe, "from leaves of sycamore," 1.vii.1922) and by him generously presented to the National Collection.

In reply to my enquiries Mr. Johnston has supplied the following notes regarding the new species:—

"It is hoped that an account dealing with the bionomics of *Lathromeris johnstoni*, sp. n., will be available later. Meanwhile, without entering into numerical details, it may be stated here that as an egg-parasite it is a very valuable agent in the control of the cotton stemborer (*Sphenoptera* sp., Fam. BUPRESTIDAE), which in its larval stages attacks cotton in the Sudan.

Lathromeris johnstoni, sp. n., ♀.

First suture nearly straight; upper mandibular edge simple.

Marginal about one and one-third times the radius; apical fringe narrow, broadening slowly; longest cilia not greatly (one-fourth or one-fifth) exceeding the radius and equalling one-fifth of the greatest width of the wing.

Fringe of hind wing one-third greater than breadth; three rows of discal cilia, the second median in position.

Mesonotum entirely longitudinally striate or finely rugose.

"The pest, though not of first importance, is widely distributed in the country. The range of the parasite seems to correspond with that of the host, since it has been found wherever the stemborer occurs.

"Up to eight *Lathromeris* adults have been observed to emerge from single *Sphenoptera* eggs, which normally are laid on the bark of the cotton plant stem.

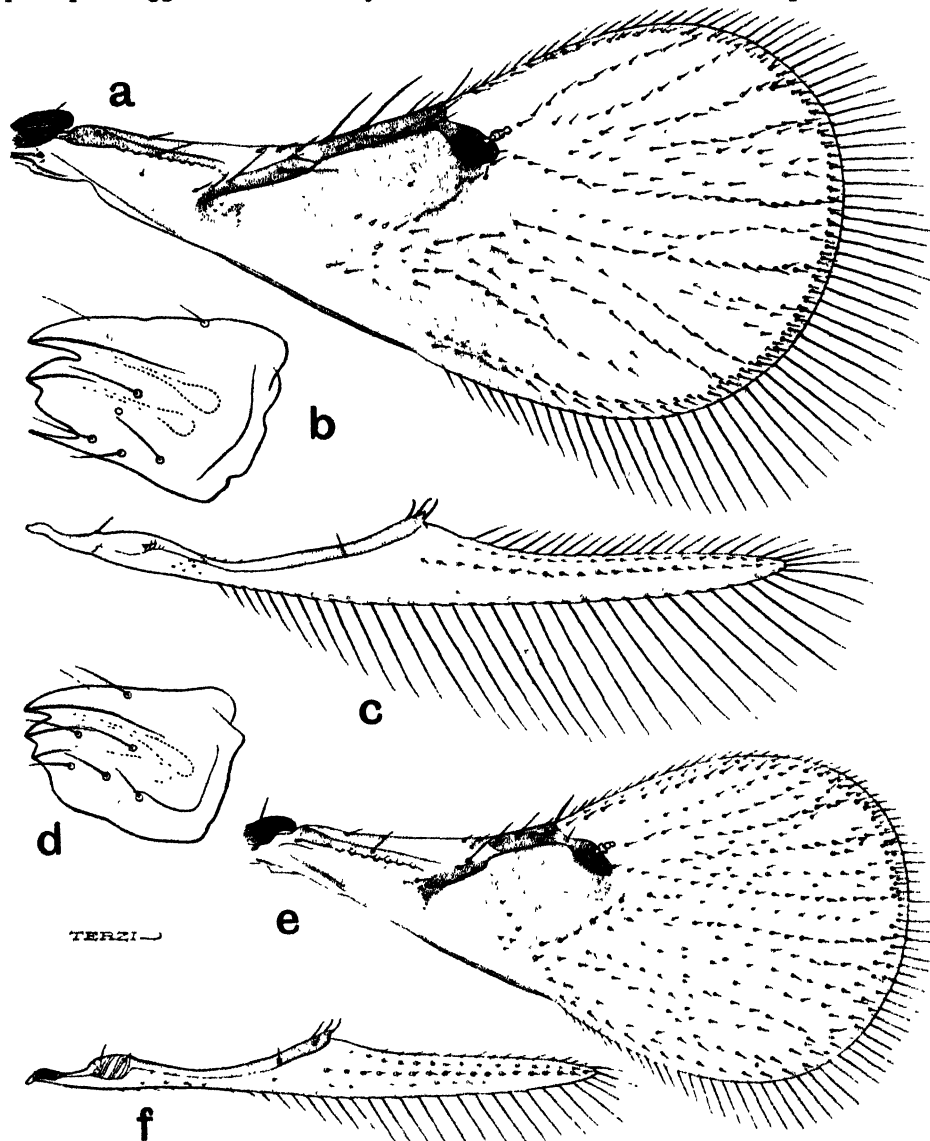


Fig. 2. *Lathromeris scutellaris*, Först., ♀: a, forewing; b, mandible; c, hind wing. *Lathromeris johnstoni*, sp. n., ♀: d, mandible; e, forewing; f, hind wing.

"The incidence of the parasite is less remarkable in the earlier stages of the cotton crop, but it increases greatly in abundance as the crop matures. It is present both in the large and localised irrigated districts, and among the more scattered areas of rain-grown cotton.

"The cotton stemborer has several known alternative wild host-plants in the Sudan. Moreover, cotton is an annual crop throughout the country. Observations made indicate that during the period between the crops numbers of *Lathromeris* continue to breed in eggs laid on these wild plants. There is no doubt, however, that large numbers perish with the destruction of the crop at the end of the season."

Since drawing up these notes I have had an opportunity of examining the series of *Sphenoptera* egg-parasites reared by Mr. Johnston in 1925. The localities range from Khartoum and its vicinity to 140 miles south. The host, when determined, appears to be *Sphenoptera gossypii*, Cotes. This material contains besides *L. johnstoni*, sp. n., a series of a small Encyrtid.

The *Lathromeris* has been reared from Khartoum to 100 miles south, and at least one batch of the host eggs occurred on *Hibiscus esculentus*.

SOME EFFECTS OF ELECTRIC CURRENT ON MOSQUITO DEVELOPMENT.

BY MALCOLM E. MACGREGOR,

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In connection with further experiments concerned with the significance of the pH of natural and other waters and the relative suitability or unsuitability to the development of the larvae of certain mosquito species, electric currents have been used to alter the pH readings, thus avoiding the necessity of adding extraneous acids or alkalis to bring about this alteration.

It has been found that wide variations in the pH index can be created in certain waters from natural mosquito breeding-places. This is effected by the electrolysis of the inorganic and organic compounds naturally present in these waters, and the subject is still under investigation.

Incidentally some interesting observations have been made on the effect the electric current has upon the mosquito larvae. In these experiments larvae and water have been placed in small glass museum jars, in which coiled platinum wire electrodes are suspended at opposite sides of the jars below the surface of the water, and direct currents of various voltages have been used. At a voltage of 100 and a roughly estimated current of 250 milliamperes passing through swamp water, the larvae of *Ochlerotatus* spp. are violently affected. They are not immediately paralysed, however, and the body muscles remain under control, so that the larvae are able to swim normally to all parts of the jar in their efforts to escape. The body of each larva, nevertheless, is contorted by involuntary muscular spasms, and within a few moments the larvae lose muscular control and swimming ceases. The twitching of the body continues for a period of about five minutes, and the larvae are then apparently dead. If such larvae are removed from the charged water and placed in a jar of uncharged water they usually recover completely within 15 minutes, and in most cases will continue their development normally. If they are allowed to remain in the charged water for longer than 5 minutes death invariably takes place. The voltages in these experiments were steadily reduced until it was found that the larvae would continue to develop when low voltages of from 2-6 volts were used. That the larvae actually feel the effects of the current at these low voltages can be demonstrated by periodically making and breaking the non-inductive circuit. As soon as the switch is closed the larvae dive and wriggle, but after a few seconds they tolerate the current and show no signs of distress. A roughly estimated current of 10 milliamperes at 4 volts is used in the jars. With this current a faint but steady stream of hydrogen gas in the form of microscopically small bubbles is evolved from the negative electrode, while the oxygen gas from the positive electrode adheres to the surface of the platinum and by coalescence of the minute primary bubbles of gas larger bubbles of oxygen temporarily adhere to the electrode until they are of sufficient size to be detached by their buoyancy. Thus the hydrogen is constantly and rapidly eliminated from the water, and from the water surface, owing to the lightness of the gas, while the retention of the oxygen renders the water and the water surface, where oxygen gas bubbles are formed, oxygen-supercharged. The larvae in such water readily take advantage of the conditions available and will attach themselves by the siphon to an adherent bubble of oxygen gas at the positive electrode while they feed for long periods below the water surface. Not infrequently, however, other parts of the bodies of the larvae come into contact with bubbles of gas, and the mouth-brushes are very apt to entangle and hold a gas bubble, which is not easily

dislodged. If the size of the bubble is not sufficient to carry the larva with it rapidly to the surface, a remarkable change is witnessed; the buoyancy of the bubble swings the body of the larva round so that the head is upwards and the siphon downwards, reversing the natural orientation. Apparently unable to appreciate the reversal of its position, the larva, as it drifts slowly upwards, seems to conclude that it is sinking, and therefore swims actively to the bottom of the jar, which it taps with its siphon in a vain endeavour to reach the air. Its non-success stimulates it to increased efforts, and these resemble the frantic struggles of larvae to reach the air when an oil film covers the water surface. Often the violent movements of the larva detaches the bubble of gas from the mouth-brushes and the larva regains its normal orientation, but in some cases I have seen larvae almost asphyxiated by their obsession that the air is to be found at the bottom of the jar.

Obviously, therefore, it would seem that Culicine mosquito larvae reach the surface by instinct which directs them to swim backwards, *i.e.*, in the direction of the siphon. The siphon end of the Culicine larva is lighter than the head and thorax, and consequently points upwards. If under abnormal conditions the orientation of the larva is reversed, so that the anterior portion of the body is lighter than the posterior, the siphon points downwards and the instinctive response of the larva leads it away from the air. Conscious appreciation of the situation of the surface film is evidently non-existent in Culicine mosquito larvae.

Under the same conditions nothing of the kind takes place with Anopheline larvae. As the Anophelines are surface-feeders only, the small gas bubbles at the surface are disrupted immediately they come into contact with the mouth-brushes, while if by a rare accident a bubble of gas adheres to the mouth-brushes while the insect is under water, the violent darting movements of the larvae soon detach such bubbles. The bodies of Anopheline larvae, moreover, even while they are swimming below the surface, and while they lie at rest at the bottom, assume a roughly horizontal position and the normal orientation is consequently not changed.

Culicine and Anopheline larvae from the first instar placed in water through which a current of 4 volts 10 milliamperes has flowed continuously have been shown to be capable of completing their development. The emergent mosquitos have not exhibited any changes in size or ornamentation. There has, however, been marked acceleration in the time taken to complete the development when compared with contemporary control experiments in which no current was used. For some reason the death rate among the larvae in the charged waters was considerably greater than among those in the uncharged waters. This is probably due, among other things, to electrolytic decomposition of chlorides, and the evolution of free chlorine. In waters containing a comparatively high percentage of chlorides it has been found that the liberation of chlorine speedily brings about the death of all the larvae. In such waters the presence of free chlorine after electrolysis is easily recognized by its characteristic smell.

It must be remembered that Culicine larvae even under natural conditions occasionally meet with an oxygen-supercharged condition of the water in their breeding-places, and that in such circumstances some species will readily avail themselves of the abnormal supplies of oxygen below the water-surface. Such a condition occurs in ponds containing large quantities of water-weeds that are open to a flood of sunshine, and the leaves and stems of the plants are often studded by temporarily adherent bubbles of oxygen, to which the larvae hang by their siphons.

During work in Mauritius in 1922 in one of the fresh-water swamps near the coast, large numbers of the larvae of *Culex quasigelidus*, Theo., were captured one day when the sky was overcast by simply scooping the surface of the water with our dippers. It so happened that on the following day when the swamp was revisited to collect additional specimens the sun shone in a cloudless sky, and I was astonished to find that, by the same measures, no further larvae could be found. Later, while

examining the swamp more carefully, thousands of the larvae of this species could be seen feeding quietly about three feet below the surface, as they hung in lines attached by their siphons to adherent oxygen gas bubbles on every submerged stem of the water-plants.

The eggs of mosquitos seem to be unaffected by electric currents. Batches of eggs have been placed in water through which current at a pressure of 150 volts has flowed for several hours. The eggs were then removed to uncharged water from the normal breeding-place, and larvae have hatched and developed successfully from these eggs. Probably the chitinous envelope of the eggs has been a sufficiently good dielectric to insulate the embryos completely from the destructive effects of the current.

OBSERVATIONS ON THE LIFE-HISTORY OF *HELOPELTIS* ON COTTON IN SOUTHERN NIGERIA.

By OWEN B. LEAN, B.Sc., D.I.C., F.E.S.

The work described in the following paper was undertaken subsequent to Mr. F. D. Golding's investigations (2), which established the significance of *Helopeltis* spp. (CAPSIDAE) to the Nigerian cotton crop, and which showed that some study of the life-history of this recent addition to the list of Nigerian insect pests was desirable.

Most of the breeding was carried out during October and November, 1924, from material collected on the Moor Plantation, Ibadan. All the breeding figures were obtained from *H. bergrothi*, Reut., but there were no apparent differences between the life-history of this species and that of *H. sanguineus*, Popp., the other species found to attack cotton, and attempts to differentiate between the nymphs were unsuccessful.

The most satisfactory arrangement for breeding was found to be by using small glass chimneys with the small end downwards and closed with a cork, and the upper end covered with fine muslin or copper gauze. A young cotton stem with developing leaves, placed in water in a small glass tube with the opening plugged with cotton wool, was then inserted in the chimney, on the bottom of which some earth had been placed. The insects were moved to fresh food in a clean and dry chimney each day.

The following notes refer to the normal life-cycle as occurring on native cotton during the growing season of the plant.

The Egg.

Being deeply buried in the tissues of the stem or leaf the eggs are difficult to discover in the field, though by holding the stem in a good transverse light the elongate, white chorionic processes may be distinguished with the naked eye.

On removal from the plant tissues the egg is seen to be elongate and rather banana-shaped, with the main axis bent in the arc of a circle to a varying degree according to the consistency of the tissue in which it is laid. At the upper exposed end there is a distinct helmet-shaped operculum, the surface of which is rather coarsely sculptured compared with the smooth surface of the greater part of the chorion. At this exposed end, but not attached to the operculum, are two long processes, one about two-thirds of the length of the other. The extremities of both these are slightly clubbed, and on and about the clubs there are a number of minute orifices, which seem to be the openings of air-tubes leading within the egg.

The following are some average measurements of the egg: Total length (excluding processes), 1.52 mm.; maximum width, 0.25 mm.; length of long process, 0.87 mm.; length of short process, 0.55 mm.; average diameter of the processes, 0.018 mm.; height of operculum, 0.10 mm.

The duration of the egg stage in 60 observed cases varied from 11 to 16 days, with an average of 12 to 13 days. After the young nymph has emerged by lifting up the operculum the empty egg is left protruding from the stem.

The Nymphal Instars.

The nymphs of every instar of *Helopeltis* may be readily distinguished from the nymphs of other Heteroptera as they bear a marked resemblance in form and colouration to the very distinctive adults. In general colour they are pale cream,

marked with bands and spots of bright red ; on the legs these spots are present as far down as to include the extreme proximal end of the tibia ; the eyes are red. All the nymphs of instars after the first bear the characteristic dorsal spine arising from the scutellum.

The bands across the abdomen in instars ii-v are subject to little variation, and are useful markings for denoting the length of the wing rudiments in the various instars. The first of these bands lies across the abdomen between the posterior pair of legs, just behind the dorsal spine ; the second lies four segments behind and the third three segments behind this. Arising from the anterior end of the third band, at either side of the mid-dorsal line, there is a prominent red mark extending forward across two segments.

First instar.—The nymphs of this instar are easily distinguished by the absence of the scutellar spine. The body is very narrow compared with its length, and is broadest across the head. The antennae are quite three times the length of the body and the legs more than twice. The rostrum extends almost to the posterior end of the abdomen. The length of the body is about 1.3 mm.

The duration of the instar is fairly constant, varying between three and four days, but more usually being four days.

Second instar.—These nymphs are distinguished from those of the foregoing instar by the fact that both the thorax and abdomen are broader than the head ; the dorsal spine is present, and the rostrum extends only a short way beyond the base of the abdomen. Wing rudiments are absent. Length about 3.0 mm.

Duration of instar : Maximum, 5 days ; minimum, 2 days ; average, 3 days.

Third instar.—The markings are all more pronounced, especially the third abdominal band. The wing-pads are now distinguishable, but do not extend much past the first abdominal band and never reach beyond the base of the posterior coxae as seen from above. Length about 3.5 mm.

Duration of instar : Maximum, 4 days ; minimum, 3 days ; average, 3.5 days.

Fourth instar.—The wing-pads are now prominent and extend to between the first and second abdominal bands, or may just reach the second band. The eyes in this and the following instar are very dark red, appearing almost purple. Length about 3.7 mm.

Duration of instar : Maximum, 5 days ; minimum, 3 days ; average, 4 days.

Fifth instar.—The wing-pads, now visible to the naked eye, extend beyond the second abdominal band, but do not reach the third, and they are slightly pigmented with red. Length about 4.5 mm.

Duration of instar : Maximum, 7 days ; minimum, 3 days ; average, 5 days.

As regards habits there is very little difference between the nymphs of the various instars. They are all to be found on the lower surface of the cotton leaves, more especially on the younger leaves towards the top of the plant. Most of the puncturing occurs on the lower surface of the lamina towards the base of the leaf, on the young and succulent leaf stems, and less commonly on the older stems. A favourite attitude of the nymphs is with the distended abdomen flexed upwards, and this is straightened out on occasion to discharge the liquid excretion on to the surface of the leaf, where the drops dry as small dark areas. They are very timid, and when a plant is approached any nymph that happens to be resting on the upper surface of a leaf will immediately hasten beneath it. Ecdysis takes place, as a rule, on the lower surface of the leaf, where the cast skins may be found. One day previous to the penultimate ecdysis the tips of the wing-pads darken. A similar effect occurs prior to the final moult, but in this case the dark colour appears some four days before ecdysis, and the wing-tip becomes quite black one day before.

Summary of Nymphal Instars.

Time of ecdysis, in days after emergence.				Duration of instar in days.			
Ecdysis.	Maximum.	Minimum.	Average.	Instar.	Maximum.	Minimum.	Average.
1	4	3	4	1	4	3	4
2	9	5	7.75	2	5	2	3
3	13	9	10.7	3	4	3	3.5
4	16	12	13.6	4	5	3	4
5	21	17	18.4	5	7	3	5
				—	—	—	—

The Adult Stage.

Any lengthy description of the characteristic adult is superfluous. Their slender form, bright red-brown colouration, long red legs and black antennae, and the remarkable erect, dorsal, pin-like spine rising from the scutellum, make the two species easily recognisable.

In the details of colouration and the size there is, however, considerable individual variation, and the separation of the species is a matter of some difficulty. In the field the adults of *sanguineus* are, as a rule, conspicuous owing to their deep and bright red colour, but some specimens of *bergrothi* approach this tint. In pinned specimens the colour differences are small.

The insects that have been considered to be *bergrothi* exhibit two quite distinct forms, characterised more particularly by the extent of the grey suffusion on the hemi-elytra. In the first form (A) the membrane is uniformly grey, and the grey colour extends into the distal portion of the corium; whereas in the second (B) the grey colouration extends across the hemi-elytra only in three bands, one at the apex of the membrane, one at the base of the membrane and one across the middle of the corium. In (A) the cuneus varies in colour from light red to nearly black, while in (B) it is always very dark. The femur also varies, the extreme distal end being red in (A), while in (B) it is nearly black.

The prominence of the ovipositor lying along the ventral surface of the abdomen of the female makes the identification of the sexes possible without recourse to a lens. In addition, the typical female exceeds the typical male very considerably in size.

No attempt has been made to determine the adult longevity, but it is likely to be considerable. Patterson (6) found adults to live for at least 70 days on cacao pods.

Copulation (in opposition) appears to occur irregularly, and the period during which the adults remain *in coitu* does not usually exceed two or three hours.

Oviposition takes place during the night and day, but more frequently at night. The process is spasmodic and the two following examples appear to be typical:—

1st day.	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	Total no. eggs laid.
<i>in cop.</i>		23 eggs	—	9	4	2	9	1	<i>in cop.</i>	dead	48
A ... 3½ hrs.	—										
<i>in cop.</i>			<i>in cop.</i>	—	4	11	10	sick	dead	—	25
B ... 1½ hrs.	—	—	3 hrs.								

In the case of (A), at any rate, this probably represents a normal period of oviposition as, owing to their bulk, it is unlikely that many more than 50 eggs are laid.

The actual deposition of a single egg occupies a minute or so after the site has once been chosen. The situations most favoured are in the small grooves on the leaf-stalks, perhaps five eggs being laid in one leaf-stalk, separated one from another by a distance of a few millimetres. The lower edges of the larger leaf-veins are also frequently chosen, and here the eggs are very difficult to find because of the hairy character of the surface. No eggs have been found in bolls.

The adults are active throughout the daytime, and when a bush is disturbed they will fly for short distances, but never rise far above the plants, and usually drop after flying about a dozen yards.

Few facts have been determined respecting the seasonal history. This insect was first noticed on cotton soon after the writer's arrival in the country at the end of August 1924; the numbers appeared on the increase until about the middle of November, after which date there was a gradual decrease, and the last adult was seen on cotton on 23rd April 1925.

Food-plants.

In Southern Nigeria *Helopeltis* seems to prefer cotton to any other food-plant and the adults and nymphs have only rarely been seen on other plants. Of the three varieties of cotton grown on Moor Plantation during the past season, the Ishan variety of the native cotton (*Gossypium vitifolium*) seems to be preferred; then in order of preference comes the Meko variety of the native cotton (*G. peruvianum*); and, finally, the American Allen variety, but although this Allen cotton is least favoured it did not escape serious infestation.

In the Annual Report of 1913 (6) the Entomologist of the Gold Coast gives a lengthy list of food-plants of *Helopeltis bergrothi*, which is a serious pest of cacao in that Colony. But it is to be noted that practically all these plants were attacked in cage experiments only, and the insects were not found on them in the field. During the ten months in which observations have been made by the writer in Nigeria this pest has been found only on two plants other than cotton. On cacao (*Theobroma cacao*) it is rarely seen, though there can be little doubt that it breeds on this plant. Both adults and immature nymphs have been observed on guava (*Psidium guajava*), more especially on the young plants, and in captivity a female was found to oviposit in the young shoots.

Mr. Golding informs me that he has found adults on the hogplum (*Spondias lutea*).

Natural Enemies.

Predators.—Although many Reduviids, Mantids and other insects, as well as spiders, undoubtedly prey on the *Helopeltis* nymphs and adults, the only observed cases were those of the larvae of a Syrphid fly, *Xanthogramma pfeifferi*, Bigot, which capture the nymphs at the time of ecdysis. This unexpected enemy was found to be of noteworthy importance.

The fully fed larva is about 8 mm. in length, and very pale green in colour, except while digesting a captured nymph, when it attains a marked red tint. The pupal period was found to be 5 days. The adult fly is of medium size; the thorax is dark shiny black, and the abdomen is rather flattened and yellow with narrow stripes of brown. The wing expanse is about 15 mm., and the length of the body about 8 mm. Mr. Golding has bred this fly on Aphids on cotton.

In his paper on the damage caused by *Helopeltis*, Mr. Golding (2) records a single instance of an adult cotton-stainer, *Dysdercus supersticiosus*, F., preying on a *Helopeltis* nymph.

Parasites.—Only one parasite, a Braconid, *Euphorus? nigricarpus*, Szép., has been obtained from *Helopeltis*, but again this is of rather special interest and importance as a natural check, at any rate during the one season in which observations have been made. The adult is a small, black-bodied insect with the legs and antennae light brown. The wing expanse is about 2.5 mm. Full details of the life-history of the parasite have not been worked out, but the essential facts have been ascertained.

The larvae of the parasite eat their way out of the host during the final nymphal instar, through the wall of the abdomen at a point usually just below the tip of one wing-pad. They emerge some considerable time after the fourth moult (in one case as much as 9 days after and never less than 6 days), then fall to the ground and immediately make their way to about half an inch below the surface of the soil, where they spin a compact white silken cocoon measuring about 2.5 mm. in length. The length of the period from the larva entering the soil to the emergence of the adult varied from 14½ to 16 days, and was usually 15 days. In the majority of cases the emerged adults were killed at once, but amongst those left alive most lived (unfed) for one day, and one only for as long as three days. After the parasite has emerged from the *Helopeltis* nymph the death of the latter does not ensue immediately; it usually lives for one day, during which the abdomen is nearly empty, crinkled and turned over to one side, so that such a nymph can be easily recognised. Several days previous to the emergence of the parasite the abdomen of the host becomes distended and has a peculiar whitish appearance, which enables the parasitised nymphs to be distinguished with care.

Nothing is known regarding the oviposition of this parasite beyond the fact that one *Helopeltis* nymph of the second instar when taken in the field was subsequently found to be parasitised, and therefore the eggs are probably laid in nymphs of the first two instars or else within the eggs of the host. If, however, we assume that oviposition takes place at the latest during the second instar of the host, it makes the total developmental period of the parasite at least 31 days, which is practically the same as the similar period of the *Helopeltis* host, a fact that reduces the controlling capacity of the parasite to a very serious extent, unless the number of eggs laid by the parasite are found to be far in excess of those laid by the host.

This parasite was bred only from *Helopeltis* taken from cotton on Moor Plantation, but in this area it was common. Possibly it became more and more abundant as the season advanced, but of this it is difficult to be sure, since it was not discovered until early October.

Two features of the bionomics of the parasite are of interest. In the first place it is one of the rare instances of a Braconid parasite of a Heteropteron, and secondly, there is the peculiarity of a Braconid pupating in the soil. Several recent papers record Braconid parasites of *Helopeltis* on tea in Java, one being a *Euphorus*, and another an *Apanteles* (Menzel (3) (4) and (5) and Bernard (1)).

Control Measures.

Whether the present status of *Helopeltis* as a pest of cotton in Nigeria is sufficient to warrant any involved system of control is open to doubt. As it is of primary importance in the Gold Coast as a pest of cacao, and as at any time it might become of greater importance on Nigerian cotton, it is thought that a review of any possible control measures will not be out of place.

Any method involving spraying, artificial manuring, pruning or hand-picking cannot be considered feasible owing to the present impossibility of improving or modifying in any way the accepted methods of cultivation practised by the native farmers in Nigeria.

In the opinion of the writer any extensive system of a close season for cotton is at the present time equally impossible, and even if this were not so, it would seem impractical to uproot the alternative food-plants, since these include cacao and, according to the cage experiments in the Gold Coast, a great number of the common bush plants.

Artificial selection may produce a strain of cotton that will not prove attractive to the *Helopeltis*, but such a selection would of necessity be a long process and one that the present status of the pest will hardly warrant.

Should the Braconid parasite subsequently be found not to occur in the Gold Coast, it would seem that an introduction might give results of great benefit to the cacao industry there.

In Nigeria, where so many control measures are impossible, there would appear few reasons against a propagation of the parasite, which could be bred in quantity and distributed over the cotton-growing area. Such a measure could hardly be expected to annihilate the *Helopeltis*, because of the lengthy life-cycle of the parasite, but it could be relied upon to check excessive multiplication. Under the peculiar conditions that obtain in this country, parasite propagation should in the future prove the most potent control measure available, and it is a measure that could be applied at once to nearly all the more important pests of the Nigerian cotton crop.

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NOTES ON THE GENUS *CHRYSOPS* (DIPTERA, TABANIDAE).

By A. STACKELBERG,

*Zoological Museum, Russian Academy of Sciences.***1. *Chrysops amurensis*, Plsk. 1910 (= *C. binoculatus*, Szilady, 1917).**

In the type of *C. amurensis*, Plsk., which is in the Zoological Museum of the Russian Academy of Sciences, the colouration cannot be considered as having attained its full development. The wings are somewhat indefinitely tinged, but there is a fairly distinct preapical spot; it is rather narrow, and is separated from the main dark part of the wing by a large pellucid portion, curving into the marginal cell; in shape and position this incurvation is similar to that of *C. dissectus*, Lw., and *C. ricardoae*, Plsk. All other features, such as the shape and size of the facial calli, the relative proportions of the different joints of the antennae, and the colour of the abdomen, are similar to those of *C. binoculatus*, Szil., as given in Szilady's description. The slight difference between the figures given by Pleske* and Szilady† in the shape of the central spot of the second tergite of the abdomen is probably due to greasing of the lateral parts. Szilady's figure presents the more normal pattern.

2. *Chrysops dissectus*, Lw. ♂.

Exterior part of the facial calli and the buccal calli blackish, interior part of the facial calli and the oral callus yellowish. 1st antennal joint yellow, 2nd brownish yellow, 3rd black. Abdomen dull black, but the two basal tergites orange yellow; base of the 1st tergite blackish, and that colour sloping down to the middle third of the hind margin; 2nd tergite with a rather large obcordate spot in the middle, extending to the black space of the 1st tergite and occupying about one-third of the width of the 2nd tergite; 3rd-6th tergites dullish black, 3rd and 4th with a rather broad greyish-dusted hind margin, which is produced anteriorly in the middle and forms a well-defined equilateral greyish-dusted triangle; the whole of the 5th and 6th tergites covered with greyish dust. 1st and 2nd basal cells brownish to the middle. Other characters as in the female.

A single male (not previously described) and some females taken by Mr. A. Emel'yanov at Imanjpo, Manchuria, 8.vi.1911. The male type is preserved in the Zoological Museum of the Russian Academy of Sciences.

3. *Chrysops suavis*, Lw., var. (= *C. sakhalinensis*, Plsk. 1910).

The species described by F. D. Pleske under the name of *C. sakhalinensis* is a merely dark form of *C. suavis*, this being a common variation. The specimens in the Zoological Museum of the Russian Academy of Sciences enable us to trace the links in the evolution of its colouration.

It must be noticed that all the specimens of this species present two large yellow lateral spots on the second tergite; more lightly coloured examples (*vide* Szilady, Arch. f. Naturg., 1917, Taf. iii, fig. 44) have—besides the medial yellow stripe on the 2nd, 3rd and 4th tergites, peculiar to that species—two rather large spots on the 3rd tergite, situated mid-way between the medial stripe and the lateral margins of the tergite. These spots are sometimes continued on the 4th tergite, but most of the specimens have the lateral parts of the abdomen darkened (fig. 46, *ibid.*), so that the only yellow parts to be seen are the two large spots of the 2nd tergite and

* Ann. Mus. Zool. Acad. Sci. St. Pétersbourg, xv, 1910, pl. iv, fig. 2c.

† Arch. f. Naturg., lxxxiii, 1917, p. 134, fig. 2.

the medial yellow stripe of the 2nd, 3rd and 4th tergites. The lateral spots (shown fig. 46, Szilady, *loc. cit.*) also sometimes disappear. Finally, var. *sakhalinensis*, Plsk. (sec. typ.) presents on the front part of its 2nd tergite not only the joining together of the black stripes, but also their union with the medial dark spot of the 1st tergite, so that the medial yellow stripe appears to be broken in front (*vide* Pleske, Ann. Mus. Zool. Acad. Sci. St. Pétersbourg, xv, 1910, pl. iv, fig. 9c).

4. *Chrysops makerovi*, Plsk. 1910 (= *C. loewi*, Kröb. 1920).

In the Zoological Museum of the Russian Academy of Sciences there are 8 females of this species, 6 of which are cotypes of *C. makerovi*, Plsk. All these examples are completely identical with Kröber's description of *C. loewi* ♀, consequently the latter species is only a synonym of *C. makerovi*. This species is very like *C. nigripes*, Ztt., but differs from it as follows: (1) The preapical spot on the wings is larger and occupies about two-thirds of the length of R_4 (in *C. nigripes* it is narrower and occupies about half of the length of R_4); (2) the 2nd tergite of the abdomen is much yellower; (3) the buccal calli are smaller and separated from the oral and facial calli by a rather large grey-dusted space (in *C. nigripes* the buccal calli are considerably larger and extend near to the facial calli).

5. *Chrysops punctifer*, Lw. (= *C. maculiventris*, Beck.).

A comparison of *C. maculiventris*, Beck. (Ann. Mus. Zool. Acad. Sci. St. Pétersbourg, xvii, 1912, p. 587) with a ♂ *C. punctifer*, Lw., from Andalusia, determined by H. Loew, together with some other specimens of the same species from South Europe and Syria, in the Osten-Sacken collection in Zool. Mus. Russ. Acad. Sci., has revealed the absolute identity of *C. maculiventris*, Beck., and *C. punctifer*, Lw.

6. *Chrysops oxianus*, Plsk., ♂ (not previously described).

By its general features and the colour of the abdomen the male of this species is very nearly related to *C. striatus*, v.d. Wulp (= *mlokosiewiszi*, Big.), from which it differs as follows: (1) The 1st basal cell is brownish only in the basal third (*C. striatus* in the basal half); (2) beyond the middle cross-vein from R_{2+3} , on a level with the discal cell, is a rather broad pellucid stripe, gradually disappearing in the discal cell; (3) the abdomen presents four not very broad black longitudinal stripes, the two medial ones uniting on the 2nd tergite and forming at the junction a black rectangle with a triangular yellow portion in its posterior part.

The ♂ *C. oxianus* differs from the ♀ in the following features: The larger extension of the black portions on the wings and the abdomen; the wings are brown-tinged in the ♂ and brownish yellow in the ♀; the transverse stripes on the wings of the ♂ are much broader and unite posteriorly (in the 4th posterior cell), the legs of the ♂ are black, the front coxae, apical part of the middle femora and basal part of the hind tibiae brownish yellow. The basal third of the front tibiae, the middle tibiae and the first joint of the middle and hind tarsi are yellow.

One ♂ was discovered by D. Kozhanchikov near Dzulek, Syr-Darya prov., Russian Turkestan, 17.viii.1910.

Chrysops subgen. *Turanochrysops*, nov.

Wings hyaline; 1st antennal joint considerably dilated, 2nd joint long, cylindrical, 3rd very long, a little longer than the two basal joints together; frontal and facial calli very large and prominent, shining yellow.

Type of subgenus: *Turanochrysops hyalipennis*, sp. nov.

***Chrysops (Turanochrysops) hyalipennis*, sp. nov.**

♀. Head yellow, frons nearly one-third the width of the head; frontal callus large, nearly extending from eye to eye, prominent, shining yellow; vertex blackish, a little yellowish pollinose; frons between the frontal callus and the vertex covered with yellow dust; the narrow, doubly arched yellowish margin extends across above the antennae, and that colour extends all round the antennae and is connected with the very narrow middle part of the face; facial calli very large and prominent (fig. 1a), especially on the middle part, broadly united with the oral callus; the latter is large, but less prominent, extends to the oral aperture and unites with the buccal calli; the buccal calli are separated from the facial calli by a yellowish pollinose narrow triangle; all the calli are shining yellow; occiput black, in the vertical part yellowish, covered with greyish dust. Pubescence of the frons, face and occiput yellow. Proboscis with rather large labella, palpi shining yellow, the 2nd joint a little dilated at the base and with pale pubescence. Antennae (fig. 1, b) very long, yellow; 1st joint considerably dilated and quite two and a-half times as long as its broadest part; 2nd joint a little shorter than the first one, thin, cylindrical, 3rd joint very long and a little longer than the two basal joints together, the latter covered with black short bristly hairs.

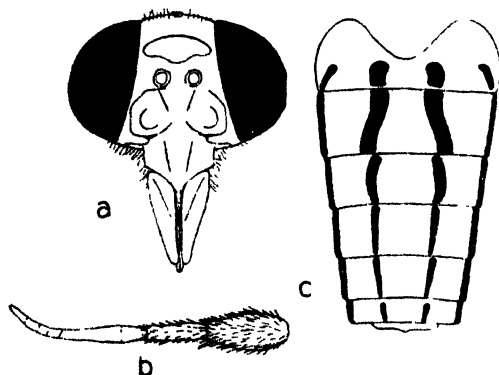


Fig. 1. *Chrysops (Turanochrysops) hyalipennis*, Stack, sp. n., ♀: a, head; b, antenna; c, abdomen.

Thorax black; mesonotum greyish with 3 black longitudinal stripes, sometimes with the ground-colour yellowish; humeral callus, upper part of the mesopleura and all hypopleura yellow, sometimes all the lateral part of the mesonotum and upper part of the pleura yellowish, pleura in the other parts black; the upper part of the sternopleura densely, the other parts of the pleura finely, covered with the greyish dust. Scutellum greyish black, sometimes with the apical part yellow.

Abdomen (fig. 1, c) pale yellow with 4 black narrow stripes, extending from the 1st to the 6th tergite (the medial ones, which are a little broader), or from the 2nd to the 6th (the lateral ones, narrower); venter yellow with 3 black stripes, the middle of which is the broadest. Pubescence on the thorax and abdomen short, yellowish.

Legs, including the coxae, pale yellow, apical part of the tarsi brownish. Pubescence on the legs composed of rather short yellowish hairs, longer only on the front coxae and the anterior femora; front and hind tibiae with blackish fringes laterally.

Wings hyaline, subcostal and 1st radial veins yellow, the others brownish black; squamae pale yellow with whitish fringes; halteres yellow, knobs rather whitish.

Length about 7.5 mm.

3 ♀♀ taken by Mr. K. Arris, near Tedzhen, Transcaspia Province, vi.1904 (type and cotypes in the Zoological Museum of the Russian Academy of Sciences, St. Petersburg).

Table of Subgenera.

- | | | | |
|--------|--|-----|--------------------------------|
| 1 (4). | Wings hyaline. | | |
| 2 (3). | Facial calli absent, 1st antennal joint cylindrical | ... | <i>Nemorius</i> , Mg. |
| 3 (2). | Facial calli large and prominent, 1st antennal joint dilated | | <i>Turanochrysops</i> , Stack. |
| 4 (1). | Wings with conspicuous black bands or markings | ... | <i>Chrysops</i> , Mg. |

THE LIFE-HISTORY OF *TECTACORIS LINEOLA*, F., AND ITS CONNECTION WITH INTERNAL BOLL ROTS IN QUEENSLAND.

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(PLATES XIV–XVI.)

CONTENTS.

Introduction.

The insect whose life-history is described in the following pages is one which is the cause of very widespread damage to cotton in Queensland. Its effect on the plant is similar to that of *Dysdercus* spp. in other cotton-growing countries, but its importance depends upon the fact that it does not replace the local species of *Dysdercus* but augments the loss which that insect causes.

Tectacoris is early in the field, even before the first flowers appear, while *Dysdercus* holds off until the opening of the bolls. In consequence of this, boll rot fungi occupy a premier position among the pests of cotton in Queensland.

It is on the coastal areas that these fungi are most likely to menace the growth of the young cotton industry, as not only is the climate more suited to fungi, but, as will be seen in the course of this paper, the higher temperatures that prevail, accompanied by high humidity, would tend to have their effect on the insect itself, increasing its rate of multiplication. The rainfall is more evenly distributed and more dependable in most of the coastal area than west of the coastal ranges, and the area is not so liable to long spells of dry weather and low humidity, which latter conditions appear to have a retarding effect on the increase of *Tectacoris* in the field.

Description of Adult *Tectacoris lineola*, F.

Length varying from 17 mm. for males to 22 mm. for females.

Head, prothorax, and scutellum orange-yellow to sanguineous, patterned with irregular patches of iridescent blue or green. Face, prothorax and abdominal segments laterally, often bordered with dark blue or emerald-green, patches of

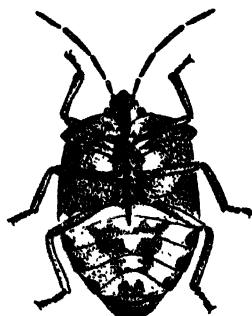


Fig. 1. Lower surface of *Tectacoris lineola*, F., ♂.

which also appear on the thoracic and abdominal sternites. On the scutellum, prothorax and head patches and bordering lines often spread until the ground-colour of yellow or red is reduced to lines forming a more or less regular figure. The prothorax often bears a marking shaped like a fleur-de-lys. This invasion

of the yellow or red areas by the blue or green markings is much more pronounced in the males than in the females.*

Ventrally, both sexes are coloured sanguineous to fuchsia-pink; in the case of the males, abdominal segments 3 to 5 bear dark brown patches (fig. 1), which apparently cover a glandular area, for a white waxy secretion often exudes from them. The legs are either black or dark blue, with the tarsi black; and the antennae and rostrum are usually black. The proboscis reaches nearly to the caudal edge of the 3rd abdominal segment and measures 8–12 mm., according to the size of the insect.

It would take up too much space to describe all the numerous varieties of patterns assumed by individuals of this species, many of which have already been figured by Mr. A. P. Dodd (Trans. Ent. Soc. Lond. 1904, pl. xxviii). A cotton plant covered with adults appears in the distance to bear some wonderful brilliant inflorescence, but it has to be seen to be appreciated to the full.

Bionomics of *Tectacoris*.

The life-history notes which follow were chiefly made on insects confined in cages of the type shown in the photograph (Pl. xiv, fig. 1). These contained one or two cotton bushes. Individual adult insects could be identified by marking numbers on the scutellum, and this method was adopted. In this way confusion of the broods was avoided. The insects lived in more favourable circumstances than would have been the case had they been kept in separate small cages, as the conditions in the large cage approximated very closely to those obtaining in the field. In addition, numerous notes on habits were made in the field in different parts of the cotton belt. *Tectacoris*, under normal summer conditions, has a long life and breeds slowly. The maximum recorded length of life was 165 days (74 days after the last moult) for a female, and 160 for a male. Extremes of heat and cold are fatal† to it and excessive heat accompanied by low humidity affects its sexual activities. For this reason it is more liable to natural control in the country west of the coastal ranges than in the coastal belt, as already stated.

Variations in the weather from day to day result in increased or decreased bodily activity. On certain bright days, with no excessive heat, the bugs fly about from bush to bush, at times taking long flights high into the air.

When thrown into the air they usually return close to the spot from whence they were thrown, travelling on a course not unlike that of a boomerang. Some individuals may, however, continue down wind, though this is unusual. The return flight is, as a rule, done at a low altitude, even when the bugs are thrown high in the first instance. Being large and fairly heavy insects they can be thrown quite a long way up before they open their wings and begin to fly. They are very easy to catch, not being at all shy, and if approached cautiously will continue feeding, even when being watched through a lens. After the last moult they will remain clustered on a plant while the cuticle hardens and make a very striking object, giving the appearance of a brilliant inflorescence. The period of the day when flight is most usual is between the hours of 10.30 a.m. and 2 p.m., and the time of greatest activity between 11 and 12 noon. The rest of the day they feed. At night they seek shelter in the plants, but do not cluster as do the nymphs. At the time of copulation and after that time and egg-laying there is less flying about.

Warm days and high relative humidity are conducive to sexual activity. Nine females from one brood, which completed its last moult on 22.i.25, fed and flew for 11 days (23.i.25–2.ii.25); 5 days before copulation flying practically ceased. In another batch they started feeding 2 days after moulting began and were active for 6 days; they fed for 11 days (22.i.25–1.ii.25). Three days later copulation began

* This blue form is var. *tagalicus*, Stål.

† After severe frost in 1924, adults were found lying dead in numbers, while nymphs were unharmed, though in another place after frost nymphs just hatching had been killed.

and laying took place four days after that. The heat wave then arrived and the males began to die, so further observations were not possible. But in general, provided that there is no excessive heat, as low humidity or sexual activity increases, flight decreases. Very little feeding takes place from the time of copulation up to the time of oviposition. What little feeding by females does occur is chiefly on green bolls. After leaving the egg-mass feeding begins again. A female may remain on her eggs for as long as 17 days.

At the time when bugs are sexually active males can be seen following females about or sitting on bolls or leaves facing them. If the female is unwilling, she oscillates her body horizontally, pivoting about the region of the middle pair of legs. Males have never been seen to mount the females. Towards the end of the copulation period the female drags the male about, pushing him at times with her posterior legs, at times fluttering her wings. At this period the male may be seen patting the female with his posterior pair of legs, but he does not push in the way the female does. Females have been seen feeding during copulation, but apparently males never do. A male can live up to 6 weeks after becoming sexually mature.

The food preference shown by bugs under observation in the cages seems to indicate that on the whole green bolls are more favoured than seed cotton, especially for the last few days preceding copulation. Notes on individuals show that one fed on seed in ripe bolls for two days, green bolls seven days, leaf-vein one day. Another during eight days fed for five of them on green bolls, and three on seed cotton. Another reversed matters and fed three days on green bolls and eight days on seed cotton, and one day on bolls, seed cotton and a green boll. The carpel wall may be selected in a boll just bursting in preference to the seed, upon which *Dysdercus* would have fed eagerly. Others gave six days to green bolls and four to seed cotton, another four to each. The bugs will sometimes pierce a leaf-vein, usually from the lower surface of the leaf.

Any puncture of a small boll seems to cause it to shed. Shedding is a usual phenomenon with cotton bolls, and the actual amount of damage done in this way by *Tectacoris* is probably not very great, as fortunately it is a slow breeder, and the cotton can set many bolls in excess of the numbers injured, unless the infestation is particularly heavy, which early in the season is seldom the case. In respect of damage of this sort, therefore, *Tectacoris* is probably, early in the season, of less importance than such an insect as the Coreid bug, *Aulacosternum nigrorubrum*, Dall., which comes early to the cotton and in some considerable numbers.

As the season advances and the *Tectacoris* population increases, the number of rotted bolls becomes greater, until the first bolls begin to open, when *Dysdercus sidae*, Montr., comes into the fields, and although some *Tectacoris* bugs are diverted to the seeds in the opening bolls, the prolific *Dysdercus* takes a hand in attacking the green bolls of the developing top crop, so that when atmospheric conditions suitable for the production of boll rots exist, the top crop is so badly stained and the lint so weakened as often to be nearly worthless.

Tectacoris nymphs and adults are attracted to open bolls and feed on the seeds, the seed coat being pierced and the embryo damaged in a manner to be described hereafter.

When feeding on a green boll *Tectacoris* either just inserts the stylets of its proboscis into the boll-wall or more rarely thrusts them in as far as they will go. When this is done the developing seeds are often pierced and damaged, and the fungus infection introduced directly into them. Information is at present lacking as to the effect of a puncture of a seed uncontaminated by fungus; this will, it is hoped, be obtained when the provision of a laboratory enables one to raise broods of sterilised bugs.* In actual field conditions damage done by the bug is nearly always complicated by fungus attacks.

* Experiments made with a sterilised needle were inconclusive.

A boll that has been attacked by *Tectacoris* can be distinguished externally by a small plug of tissue that protrudes from the wound, and internally by the proliferation of the boll-wall forming a callus or excrescence, the interior of which contains a brown stain marking the track of the stylets. The response of the boll-wall tissue is similar to that described by other writers in the case of attack by species of *Dysdercus*. If a boll that has only just been pierced is cut through the wound, a small core of tissue can be seen on the interior corresponding with that on the exterior of the wound, and a circular spot appearing pale green shows up on the inner carpel wall.

When detailed observations on *Tectacoris* were begun, that is in October 1924, all adults seen were on the experimental "standover" cotton feeding on the seeds from the previous year's crop. The first adult was seen in the field on 10th October; it was a blue and red male. None had been seen for some days prior to this. This male was sitting on a ratoon plant next to the standover plot. By the 11th November the population in the acre of standover cotton was 69 (31 males and 38 females). This standover cotton had been killed down to the roots by frost, but was sprouting and setting squares. The next adults found were in the ratoon plots, which by this time had begun to flower, and a few small bolls were set (flowering 7.xi.25). Another adult was seen flying towards the ratoon at 11.30 a.m. on 8th November; another arrival was noted on the following day. The first eggs were laid presumably on or about 6.xi.25, they were found on 11.xi.25 and hatched on 24.xi.25. These eggs were laid just before the first flowering. This meant that by the time the nymphs were in the second instar there would be half-grown green bolls in the field for them to feed on (21-28 days).

Farther west from the ratoon plot was a larger area of cotton sown 30.ix.24. First squaring began about 9.xi.24 and the first flowers on 30.xi.24. On 21st and 24th October two adults were seen in this plot, a male and a female.

To the north-east of this sown area was another acre sown 7th October, in which the first squares set on 18th November, first flowers 9th December. An egg-mass with female guarding it was found on 4.xii.24. Second instar nymphs from these eggs would find bolls three weeks old for them to feed on. A neighbouring plot of cotton sown 15.xi.24 with no squares had at this time no *Tectacoris*. The ratoon plots, which were well in advance of the sown ones with their bolls and flowers, were by this time (29.xi.24) becoming more thickly populated with migrants, four having been found on one plant. Observations then point to the fact that fields may be entered a week before flowering, and eggs may be laid some days previous to the appearance of the earliest flowers. At Biloela the first adults to arrive must have gone to the standover cotton, fed and copulated there and spread afterwards to the ratoon, and thence to the annual cotton. It is significant that when *Tectacoris* adults were required for experimental purposes, one always went to the south side of the farm (where the standover and ratoon plots were situated) to collect them, and throughout the season they were far more numerous in that area.

The annual plot (one acre) next to the ratoon, planted on 6th October, proved more attractive to *Tectacoris* as the season proceeded. This one can understand, as the annual cotton was now in the stage at which the ratoon had been a month before and was therefore attractive to the gravid females.

A count made 13.i.25 showed on the ratoon that flowered 7th November, 172 adults (68 females and 104 males) and 17 egg-masses. The annual examined next day (flowered 9th December) gave 90 females, 71 males, and 30 egg-masses. A larger number of females were on eggs on the annual than on the ratoon. These individuals had not been bred from eggs laid in November, as there had not been time for them to become sexually mature. Some were from their colouration old females and may have been on their second or third batch of eggs, some had fairly recently

emerged. These then would all be migrants which had been arriving between November and the middle of January. It was not discovered whence these migrants came; none was seen in the "bottle trees" or wilga scrub in the very early spring. They may have come from scrub to the south of the farm about one mile or two miles away.

This was the case at Biloela, which is situated in a newly opened settlement, with not much cotton about the previous year, as the selections were only then being taken up and fenced. Two years previously cotton had been grown about two or three miles away and left to standover.

At other places between Biloela and Rockhampton and on the coastal areas, *Tectacoris* was laying and well established in the numerous fields of standover cotton in the middle of October. Egg-masses had hatched and adults were in copulation at Gatton about 50 miles from Brisbane and at an altitude of 300 feet on 12th November. These eggs were probably laid in the third week of October, earlier therefore than at Biloela. These again were laid on ratoon cotton which had some bolls three-quarters grown. It was more advanced than the ratoon at Biloela, as it had been treated (some of it) differently. This ratooned cotton flowered between 8.x.24 and 5.xi.24. Adults could be expected to arrive from 1st October onwards.

It is safe to assume that infestation will begin in the fields about a week before flowering. For how long the fields are infested from outside is not known yet. It may be noted here that adults were found in copulation (males of blue variety) on *Hibiscus divaricatus* near Eidsvold, on the Upper Burnett, on 28th September. Third instar nymphs were on the same bush. These may have been overwintering nymphs or been produced from eggs laid in August or late July. Hollywell Scrub, where these were found, is about 500 feet above sea-level and is situated west of the coastal ranges.

The proportion of males to females varies slightly. Counts made from bugs collected in the field showed females 48.5 per cent. and 47.4 per cent. and 55 per cent., and from a brood raised in cages 57 per cent.

Some mention should be made of the habit the female has of sitting over or near her eggs. She will remain clinging to them for as long as they take to hatch, that is some 17 days. She can often be seen waving her body from side to side and she will twist round the egg-mass from above to beneath. When an attempt is made to remove her she will cling most tenaciously. A female was seen moving this way and that and agitating her body while three Chalcid parasites were trying to dodge her and have time to lay their eggs. Eggs thus guarded seem to be protected from predacious insects. At other times the eggs may be left and the mother may be found near by sitting on a leaf but behaving as though she were still on the egg-mass. *Tectacoris* is a most accommodating insect to work with, for a female can be removed from her egg-mass and placed on a leaf while the eggs are counted, and then replaced on the eggs. With constant handling they become very tame and can be conveniently "branded" with Indian ink for identification. The junior author branded all females with even numbers and males with odd numbers, and was thus able to identify each individual.

Mention has been made of the wonderful variety* of colour displayed by *Tectacoris*, both males and females. Early in the spring and in the autumn there is an increase of the blue and red marked adults; these are practically always males. Some few females display a similar colouration, but never with quite such an increase of the blue or blue-green areas and restriction of the orange or red.

* This colour variation has been the cause of *T. lineola* having many synonyms. All kinds of colouration will be found in one brood.

Of the broods under observation the males were the first to become adult, taking 75-77 days as against the females' 76½-77 days; out of 20 adults in one brood the first six to go through the last moult were males. In another brood males completed their nymphal life in 70½ to 72 days, the females in 71 to 73 days; the first ten adults were males out of a total of 45. From 2 to 3 days elapse between emergence and first feeding in both sexes. Immediately after moulting the insects are a very brilliant orange or orange-red, in all stages.

Males can be distinguished from the females not only by their size, being on the whole smaller, though some females are as small as large males, but also by a kidney-shaped patch covering three segments on the venter or three spots placed so as to form a kidney-shaped mark. This marking is caused by the massing of very minute spiniferous tubercles. Sometimes there is a white waxy secretion from these areas, the cause and significance of which has not been ascertained. It is not present when the insects first become adult and does not correspond with times of copulation; it may be rubbed off and will grow again.

The approximate age of individuals can be gauged by their colour. Nymphs and adults that have just moulted appear orange, yellow-orange, or suffused with pink, attaining their normal colouring about two hours after moulting. At first the colours are very bright, bright blues and purples predominating in the nymphs and in many of the adults, more particularly the males. The blues later change to bluish green and to golden green as age increases. In adults orange takes the place of red as they grow old and yellow the place of orange.

In the case of the females, the venter, which is often a fuchsia pink, becomes orange or orange-red and even almost white. This latter change gives an indication as to whether a new brood has recently emerged.

Detailed Life-history.

From eggs collected in the field the following table shows the variation in numbers:—

Date.	Egg-masses.	Average per egg-mass.
14.xi.1924 ...	4	84.5
6-12.i.25 ...	14	110
9-15.iv.25 ...	13	103.6
22.iv.25 ...	11	101
8.xii.24 ...	3	84.3

All from
Biloea.
From Gatton

The number of eggs in an egg-mass laid by females of the same batch was fairly uniform, although the averages differ between one batch and another.

	Brood I. 16 ii.25 to 1.iii.25	Brood II. 6-12.ii.25	Brood III. 12-21.iii.25	Brood IV. 22.iv.25 to 5.v.25
No. eggs ...	98	111	69	70
	88	123	84	77
	85	116	60	78
	80	103	65	84
	87	120	31	93
	—	128	80	91
	—	127	76	97
	—	124	—	98
	—	—	—	98
	—	—	—	59
	—	—	—	67
Averages ...	87	109	66	83

Brood I. The insects were in the adult stage during the heat wave.

Brood III. Was not normal, as many females died without laying and others laid infertile eggs.

Brood IV. Many bugs were killed by weather conditions.

The question as to whether temperature and rainfall have any effect on the number of eggs per egg-mass requires further investigation.

The Egg.—The eggs are roughly pear-shaped and 1.9 mm. in length. The distal ends are hemispherical and the sides straight. The greatest diameter at 1.4 mm., the smallest 0.7 mm. (point of attachment). The upper end has a shining circular area with a circumferential border of small callosities, the remainder of the shell being opaque and frosted in appearance. The shell breaks to permit the egress of the nymph at the point of greatest diameter. The eggs are laid round a twig or leaf-petiole, generally on one with an upward slope. Some were laid on dry twigs on the standover cotton. One case was seen where the female began laying too close to the lamina, and eggs were laid on the lamina instead of on the petiole. A case was seen elsewhere of eggs laid on the upper surface of a leaf and none on the petiole. The time taken to lay is 2–2½ hours, perhaps some 46 eggs an hour. The female does not always lay her eggs in the same direction; she will work round the petiole clockwise, and then change to counter-clockwise. She may even leave a row incomplete and start another. When laying, the tip of the abdomen is placed between two eggs and as the egg is passed out the abdomen is raised, leaving the newly laid egg glued to the stem and the two neighbouring eggs. Oviposition may take place at any time of the day.

The incubation period varies from just over 16 days to 22 days. Some eggs under not very normal conditions (kept in a tube and brought from Biloela to Brisbane, 400 miles) took 30–34 days and 46 days (May to beginning of June). The egg period is much influenced by seasonal changes.

First Instar Nymph.—The freshly emerged nymph is just under 2 mm. in length, very bright orange-yellow to orange-red, with the eyes dark. The description of this instar, which occupies about 8 days during the cotton season, is as follows:—

Length, 2.5 mm. approximately. Head and thorax metallic blue or green, a median thin yellow stripe on all three segments of thorax in middle line. Antennae pitchy black with red at distal and proximal end of each segment; the last segment clavate. Legs fuliginous; tarsi with 2 joints. Rostrum fuliginous, reaching beyond posterior legs. Abdomen yellow orange to reddish orange; median black marking occupying one-third to two-thirds of each tergite, 4 and 5 bordered with yellow. Sternum black, venter orange. Each sternite and tergite bordered with black.

Just after hatching the first instar nymphs are gregarious on the petiole for two days; after four days they have collected on the lower side of a leaf, still in a bunch. If the leaf is turned over they seek the shady side, returning to their original place when the leaf is allowed to resume its normal position. They remain feeding until the eighth day, when moulting begins. Nymphs from eggs which had been laid on the frosted twigs of standover cotton fed on the unhatched eggs. This habit was also seen when nymphs and eggs were confined in tubes for observations on parasitism.

Second Instar Nymph.—Immediately after moulting they are the same colour as freshly-hatched nymphs. As the instar grows older blue turns to green, then to olive green. These changes take place respectively 2 and 3 days after moulting. This stage occupies 11–13 days.

Length, 5 mm. Antennae with four segments; terminal segment longer than each of the other three, less clavate than in preceding instar, set with hairs. Legs, antennae and rostrum black. Thorax blue, blue-green to bronze-green. Abdomen orange-red, median markings dark metallic green, much reduced in comparison with

previous instar. Markings absent on the penultimate segment ; segments bordered with black, these black spots not coalescing, but separate. Venter orange-red, with paired median dark markings from 4th segment. Proboscis reaching caudal edge of 3rd segment.

The second instar nymphs wander a good deal, feeding on squares or green bolls. They will collect again, perhaps, all on the one boll, but they may change their place of feeding several times. In spite of this wandering habit the gregarious instinct is still strong. Where seed cotton is available they will feed on it, but there is no particular preference for it. Some have been seen feeding on fairly woody stems. The individuals of any one batch generally collect together for the night. If disturbed they migrate, but before doing so oscillate the abdomen from side to side, keeping it pressed close to the surface on which they are resting. Feeding becomes less as the time for moulting approaches, and when moulting is about to take place they all collect in one spot. Feeding is general for eight days out of the 12 or 13 occupied by this stage.

Third Instar Nymph.—Colouring similar to the previous instar. Feeding takes place on green bolls or seed cotton, and in one case the nymphs were seen attacking an egg-mass on which the mother was still sitting.

Fourth Instar Nymph.—Length, 9 mm. Metallic blue-green. Eyes reddish brown. Legs and antennae deep metallic blue ; antennae covered with black pubescence. Thorax metallic blue-green, a red marking on prothorax, roughly triangular with base towards the head. Mesothorax with medium orange longitudinal stripe. Abdominal segment 2 suffused with fuscous laterally, otherwise red except for a broad blue-green transverse stripe ; 3 with very small amount of red and fuscous suffusion over whole segment not covered by central metallic green stripe ; 4 and 5 fuscous bronze-green on lateral border, as are all abdominal segments ; the remaining segments red with the median bronze-green band smaller. The whole of the green markings on the dorsum of the abdomen form a heart-shaped pattern with the apex towards the 1st abdominal segment. Abdominal segments 4 and 5 and the prothorax bear calli. On the prothorax the calli are paired, on the abdominal segments single and medianly placed, on the mesothorax present but not so pronounced. Wing-pads indicated, as is also the scutellum. Metathorax hardly visible. First joint of proboscis, coxae of antennae and median legs brown. Rostrum reaching almost to caudal edge of penultimate abdominal segment. Colour of venter brick-red, bordered with metallic green, with central dark markings on each segment. Thick pubescence on tarsal joints.

Feeding starts two days after moulting, chiefly on green bolls ; a few may delay in beginning to feed, but this is not the normal procedure. There is the usual clustering under cover at nightfall and during the hot time of the day. Nymphs come to the upper surface of the leaf after rain, even if the sun is shining and in the middle of the day. During the two or three days prior to moulting, when apparently feeding does not take place, the nymphs do not remain in the same place, but wander about ; they may often be seen clustered at the top of a plant. The duration of the fourth instar from the records appeared to be from 9 to 11 days, during 3 to 5 days of which there is no feeding.

Fifth Instar Nymph.—The head, prothorax, scutellum and wingpads blue-green to bronze-green, according to age. Tylus orange, prothorax bordered laterally with orange and bearing a roughly wedge-shaped marking with the apex pointing posteriorly. Two calli are present on the prothorax, which interrupt the straight sides of the wedge-shaped marking. The scutellum carries a median orange stripe. The abdominal markings are similar to those of the fourth instar. The legs are very dark blue-green, appearing almost black. The antennae fuscous, four-segmented, the second longer than the third or fourth (2.7 : 2.2 : 1.9 mm.). The rostrum reaches to the middle of the fourth abdominal segment.

This stage is very active, and there is a greater tendency to scatter than in the previous instar. Groups are, however, often formed, especially at the time of moulting. The actual time occupied by the process of moulting is 20–37 minutes. A split starts in the mid-dorsal region of the thorax, widening and extending as the nymph forces its way out of the old skin. Moulting appears to take place head downwards, and before this happens the nymph can be seen settling itself into position and getting a firm hold of the leaf surface on which it has located itself. As soon as it is free from its skin it moves and faces head upwards. The normal colour is assumed in about an hour and a half or an hour and three-quarters. For the last moult, although clustering is frequent, nymphs sometimes are found by themselves. Adults at times wander before they have acquired their normal colouration, becoming quiescent later. On the other hand, they may be seen clustered together at the top of a cotton plant, in which case they form a most attractive spectacle with their brilliant colouring of orange, red and pink.

The Connection of *Tectacoris lineola*, F., with Boll Rot Infestation.

It would, perhaps, be as well at the outset to explain that cotton research in Queensland being in its infancy, very detailed investigations are not yet possible, and a great amount of preliminary information has to be collected before this can be attempted. Facilities for accurate measurements of humidity and other meteorological factors affecting insects and fungi are lacking. Absence of labour such as is available in other tropical countries and the necessity for doing everything oneself, whether of a scientific or domestic nature, limits the activities of the would-be investigator.

This accounts for the small numbers which have been used in the following experiments. Even so, larger numbers would have been taken had not an unexpected heat wave stopped the flowering of the cotton for about three weeks and caused a large amount of boll and square shedding.

During the preliminary examination of the Queensland cotton areas towards the end of the 1923–24 season the prevalence of internal boll rots not following on the attack of bollworms forced itself on our attention, more especially in the coastal areas. *Tectacoris lineola* was in great abundance everywhere and was selected therefore as being the most likely insect to be responsible.

The next in importance is *Dysdercus sidae*, Montr., which is placed second, as it has not so long to work on the cotton as has *Tectacoris*, owing to its habit of waiting until the first bolls are ripe before coming to the fields,* whereas *Tectacoris* is there very early in the season, even before the first flowers appear. There is nearly everywhere an abundance of wild food-plants for *Dysdercus*, as the cotton area, which is scattered over some 750 by 150 miles of country, consists mostly of small patches of cultivation in the midst of many square miles of forest or scrub land.

The cotton belt can be roughly divided into two areas, separated from one another by the coastal ranges, that which lies behind the coastal ranges having altitudes varying from 100 to over 1,000 ft. The coastal area (and up to 25 miles from it) has a fairly constant rainfall, and its climate appears to favour fungous diseases. In the inland area the rainfall is much more uncertain, and frost to some extent helps to control insect pests.

Only one experimental farm was available for carrying on research work in any detail, and here conditions were far from ideal. It was situated some 75 miles from the coast, behind the ranges, and experienced very dry conditions during most of the growing season. The total rainfall was fairly good, but distributed unevenly (fig. 2).

* Cf. C. J. Withycombe, Bull. Ent. Res., xv, p. 171.

Rainfall is apt to be of a torrential nature, a heavy precipitation taking place in a short time. No farm exists in the coastal area, although it is there that boll rot investigations could be more satisfactorily conducted.

The experiments to be described were carried on as follows: Two acres of Durango cotton were put at our disposal on the Cotton Research Farm at Biloela. As the crop began to flower, just opened flowers or buds about to open were enclosed in cages of cotton voile, one flower to each cage (Pl. xiv. fig. 2). Shortly after this had been started a heat wave set in, and many buds and small bolls were shed; moreover, the plants practically ceased to flower for some three weeks, so that the work was seriously hindered. In the end 40 cages survived for use with insects together with some 35 controls; some of these latter, being bagged rather later than those used for the insects, experienced drought conditions and produced very small bolls. Finally, 25 bolls were used as controls, being fairly representative of the type of boll found in the rest of the field. A *Tectacoris* adult was placed in each of 20 cages when the boll was about 14 days old, and the insects were left in the cage 7-10 days; they were then removed and the bolls harvested when mature. The bolls were left to mature, as it was desirable to note the number of seeds damaged and the type of damage as well as the incidence of stain on the lint.

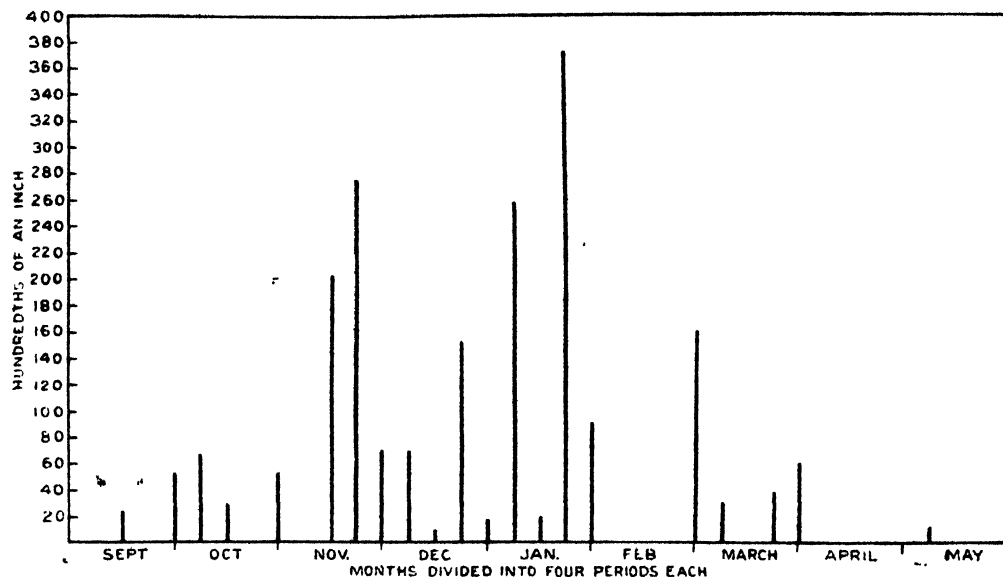


Fig. 2. Distribution of rainfall at Biloela Cotton Research Farm, Central Queensland.

The following tables give the results of these experiments. There are in all probability several fungi* and bacteria concerned, but of the fungi *Fusarium moniliforme* has alone been isolated from the seeds.† During the time the bolls were maturing and just after the insects had been put on the bolls a period of high tempera-

* The following fungi have been bred from samples of Queensland cotton, besides *F. moniliforme*: *Aspergillus niger*, *A. flavus*, *A. nidulans*, *Cladosporium herbarium*, *Rhizopus arrhizus*, and *Alternaria* sp.

† Identification kindly undertaken by the Imperial College of Science and Technology, on behalf of the Empire Cotton Growing Corporation.

tures set in, which was very unfavourable for fungus development. Owing to circumstances which need not be discussed here, no satisfactory humidity records were kept.

No. of cage.	No. of locks.	Insect put in.	Removed	Stain.	No of seeds destroyed.	Remarks.
1 ...	5	24.i.25	2.ii.25	+	1	
2 ...	5	26.i.25	2.ii.25	+	6	Slight staining
3 ...	4	24.i.25	?	+	18	Very severe deformity and stain.
4 ...	4	24.i.25	2.ii.25	+	3	
5 ...	4	26.i.25	6.ii.25	+	2	Slight.
6 ...	4	26.i.25	2.ii.25	+	3	
7 ...	4	25.i.25	2.ii.25	+	32	Very severe fungus infection.
8 ...	4	27.i.25	7.ii.25	+	16	
9 ...	5	26.i.25	2.ii.25	+	—	
10 ...	4	25.i.25	7.ii.25	+	18	Very severe fungus infection.
11 ...	5	26.i.25	2.ii.25	+	1*	Very slight. *Under puncture scar.
12 ...	—	—	—	—	—	No record, cotton removed from cage by a visitor.
13 ...	4	26.i.25	6.ii.25	+	4	Very slight.
14 ...	4	26.i.25	2.ii.25	+	7	
15 ...	4	28.i.25	No record.	+	12	Very severe infection.
16 ...	4	26.i.25	2.ii.25	+	16	
17 ...	4	26.i.25	6.ii.25	+	10	
18 ...	5	26.i.25	7.ii.25	+	8	
19 ...	4	26.i.25	7.ii.25	+	1	Very slight infection.
20a ...	5	2.ii.25	6.ii.25	+	—	Slight infection.

The figures given below show the results of the detailed examination of two locks from boll No. 8, which showed stain on the affected lock.

Affected lock.
9 seeds.

Length of fibre in mm.

Condition of seed.

27 weak and wasty
25 weak
25 "
25 "
25 "
22 very weak
24 " "
23 " "
23 " "

Partially shrunken embryo.
Sound.
Shrunken embryo.
" "
Sound.
Drought effect on embryo.
" " "
" " "
Sound.

Unaffected lock from same boll.

7 seeds

28 }
27 }
28 } All lint very
28 } strong and
27 } regular.
28 }

Sound.
"
"
"
Showed drought effect.

None of the controls showed any damage or similar symptoms, except one, the cage of which had been torn.

Bolls from three flowers which had been bagged were allowed to open, and *Tectacoris* adults were then placed on them for a certain number of days.

Date of bagging.	Insect put in.	No. of locks.	No. of seeds.	No. of seeds damaged.
28.i.25 ...	12.iii.25, removed 17.iii.25 ...	4	33	Nil
26.i.25 ...	12.iii.25, alive on 23.iii.25 ...	4	30	5
26.i.25 ...	12.iii.25, dead 17.iii.25; another 18.iii.25, dead 23.iii.25. ...	4	30	2

The results obtained from similar experiments conducted with *Dysdercus sidae* are given for comparison :—

No. of cage.	No. of locks.	Insect put in.	Removed.	Presence or absence of stain.	No. of seeds destroyed.	Remarks.
1a ...	5	3.ii.25	?	+	1	Very slight stain.
2 ...	5	27.i.25	7.ii.25	+	1	
3 ...	5	27.i.25	5.ii.25	—	0	
4 ...	5	27.i.25	5.ii.25	+	1	
5 ...	4	28.i.25	5.ii.25	+	5	Insects both dead on this date. Male and female.
6 ...	5	28.i.25	5.ii.25	+	11	
7 ...	5	28.i.25	5.ii.25	+	0	
8 ...	5	28.i.25	2.ii.25	—	0	
9 ...	4	27.i.25	7.ii.25	+	5	Very slight stain. Insect dead on this date.
10 ...	4	28.i.25	5.ii.25	+	0	
11 ...	5	27.i.25	7.ii.25	+	13	
12 ...	4	27.i.25	6.ii.25	+	1	
13 ...	5	27.i.25	5.ii.25	+	0	Insect dead between these dates.
14 ...	5	28.i.25	6.ii.25	+	7	
15 ...	5	28.i.25	6.ii.25	+	9	
16 ...	5	26.i.25	5-6.ii.25	+	0	
18 ...	5	27.i.25	6.ii.25	+	0	Very slight stain.
19 ...	4	27.i.25	5.ii.25	—	0	
20 ...	4	28.i.25	?	—	0	Insect gone and Tachinid puparium found in cage

Some counts were made from groups of ten plants taken in three different parts of the farm. These counts were partly taken for another purpose, but also show the loss due to boll-rot fungi in this season on the Cotton Research Farm. It is probably fairly representative of actual loss, although larger numbers would have been preferable. The loss from bollworms includes *Heliothis obsoleta*, *Earias huegeli* and *Platyedra gossypiella*. Except for one plot on the south side of the farm, only one picking was yielded by the plots on which counts were made. Pickings gave from 850 to 1,450 lb. to the acre.

Accurate figures of infection from *Platyedra gossypiella* were not taken, or attempted, but it formed only a very small percentage of the whole. *Earias huegeli* also was only feebly represented, and most of the loss was due to *Heliothis*.

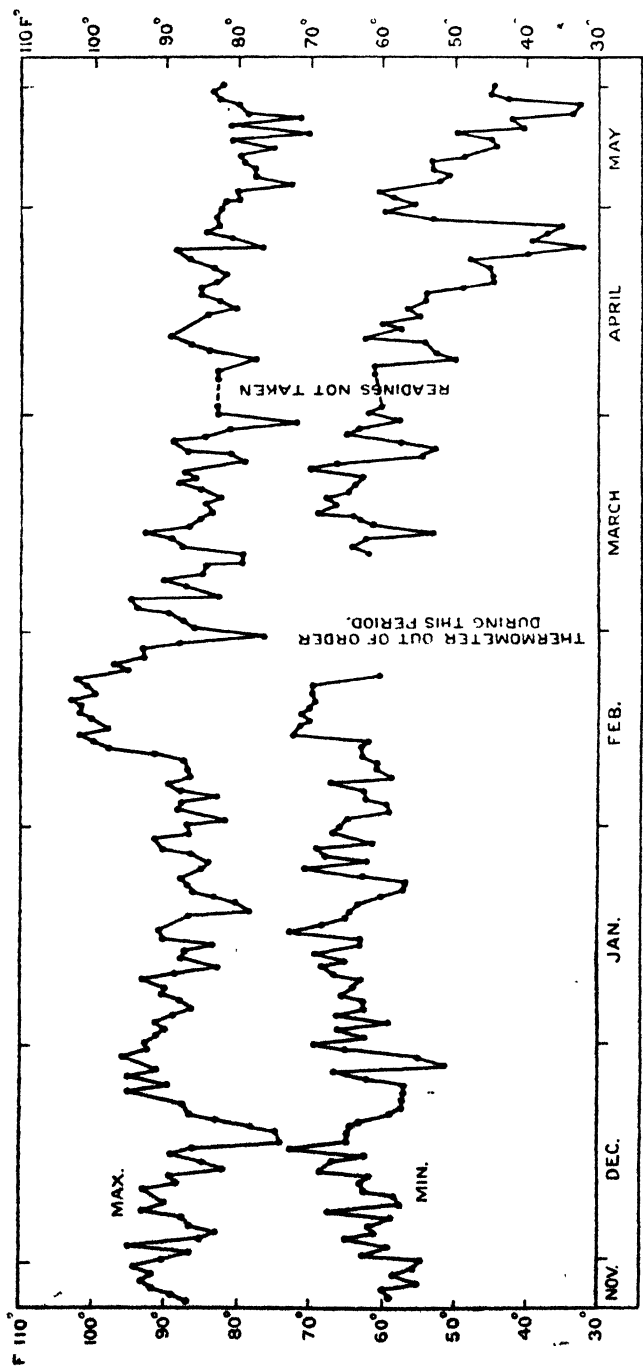


Fig. 3. Maximum and minimum daily temperatures, November 1924 to May 1925, at the Cotton Research Farm, Bilola.

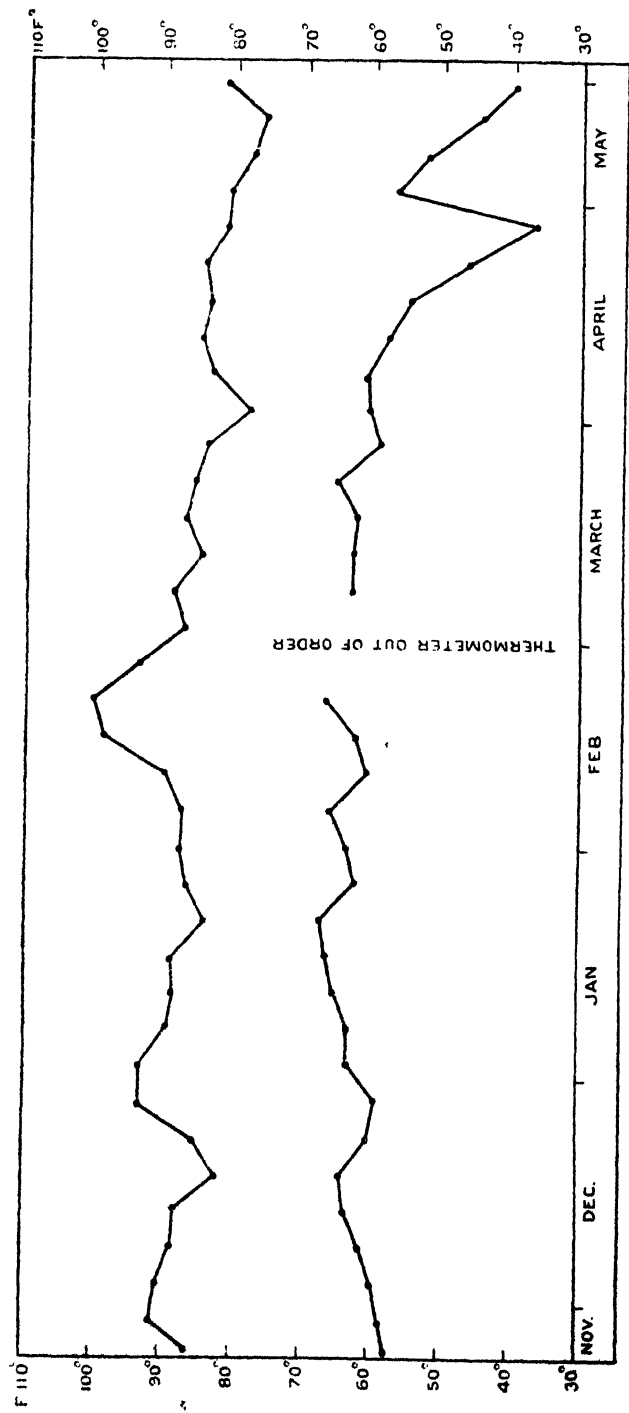


Fig. 4. Minimum and maximum temperatures for five-day periods during the same season.

In other parts of the State, where the unusually dry conditions obtaining at Biloela were not experienced, and picking and boll production continued for some time after picking at Biloela was over, additional loss was caused by larvae of a Pyralid moth, *Conogethes (Dichocrocis) punctiferalis*, attacking the later maturing bolls which should form the second picking. Such bolls are practically always badly attacked by fungi, as *Conogethes* always keeps a large hole open in the manner of *Earias*.

The combined attention of *Tectacoris* and *Dysdercus*, however, produces a greater amount of damage than is caused by the activities of *Conogethes*.

The table does not show the loss due to boll worms alone, as this only amounts to 1.45 per cent. of the total loss due to all bollworms. Boll worm attack is practically always aggravated by fungi. The table shows, in terms of locks destroyed, the loss from internal boll rots due to wounds by Hemiptera and those due to bollworms and boll rots combined.

These counts were made on dry bolls between 9.iii.25 and 27.iv.25, when the crops were ready for picking; except on one plot, only one picking was taken.

For plant groups.	Boll rots, per cent damaged.	Boll rots and boll worms.	Combined loss.	
1	7.3	7.6	14.9	All except Nos. 10-14 had maize in vicinity. Nos. 10-14 were some 250 ft. from the nearest maize at the lower end of the plot.
2	6.1	6.2	12.3	
3	5.5	5.4	10.9	
4	10.6	5.8	15.4	
5	8.0	2.3	10.3	
6	5.6	10.5	16.1	
7	11.1	4.9	16.0	
8	7.4	12.0	19.4	This maize undoubtedly kept the <i>Heliothis</i> population on the cotton low during the early part of the season. <i>Platyedra</i> attack heaviest on Nos. 1, 4 and 5.
9	6.9	6.8	13.7	
10	9.8	10.6	20.4	
11	2.8	5.0	7.3	
12	1.5	5.0	6.5	
13	7.3	20.1	27.4	
14	9.1	10.6	19.7	
15	10.2	4.5	14.7	
16	19.7	6.3	26.0	
17	12.2	6.1	18.3	

Total number of bolls 4,519

Total number of locks 19,679

Average percentage of bolls damaged by boll rots, 8.3 ± 0.65

Average percentage of bolls damaged by bollworms, 7.6 ± 0.64

A smaller sample was sent from Monal State Farm, where a more generous rainfall had been received.

All bolls from 5 plants (early) gave boll rot 11.49 per cent. and bollworm 4.8 per cent.

All bolls from 5 plants (late) gave boll rot 15.5 per cent. and bollworm 4.7 per cent.

The loss for the whole farm at Biloela (35 acres of cotton) is estimated at roughly £90 on this year's crop, from boll rots and bollworms combined. This was estimated on a basis of 3,800 plants to the acre and 120 bolls to the pound of seed cotton, which is about what was received this year owing to the bolls being small and light as a result of the hot weather. Normally they should go 70 to 80 to the pound of seed cotton.

During a visit to a farm in the coast area made in April, a count was made of 100 green bolls taken at random from plants at different parts of a 30 acre block. These on examination showed 50 per cent. bolls infected with boll rots due to bug

punctures (chiefly *Tectacoris*), 27 per cent. *Conogethes* (*Dichocrocis*) *punctiferalis*, and 6 per cent. *Platyedra gossypiella*. *Tectacoris lineola* is fortunately a rather lethargic animal. If it were not so the boll rot incidence would be still higher.

The symptoms exhibited by infected bolls are similar to those described from other parts of the world. The internal walls of the carpels show proliferation where the wound has been made, or a small translucent green area with a central dark spot. The lint is weak and "wastey," and stained brown. Where the seeds have been punctured, greenish brown discolouration occurs in the embryo, often accompanied by shrinking and deformity. The affected locks in bad cases do not split and are in any case generally deformed. Apart from the weakness of the fibre caused by boll rots the cotton is lowered in grade by the presence of the stain. At present such cotton is graded as seed cotton, and the farmers receive their price on this (Pl. xv).

The fungus which up to the present has been identified as genuinely parasitic is *Fusarium moniliforme*. This is the one that causes so much damage to the embryos in pierced seeds and follows on attacks by *Tectacoris lineola* and *Dysdercus sidae* on green bolls, and also by *Oxycarenus luctuosus* as well as the others on the open bolls.

The damage to the seed may take place in the green boll or in the open boll. In either case, where the embryo survives at all, the symptoms shown are similar (see Pl. xvi). These consist of a greenish brown stain, accompanied sometimes by a shrinking of the whole embryo and by a certain amount of disintegration in the affected area. The fungus may attack the radicle only, or the cotyledons, or both. Sometimes the stylets of the insect only just pierce the embryo, when a reddish stain or spot is seen consisting of damaged cells. When placed in an incubator for germination, seeds infected with the disease either do not germinate, or the root is produced and later dies off, showing a brown ring of shrunken tissue about midway along it. Seeds that have failed to germinate, if cut open, exhibit a brown and slimy mass inside.

Many details of the optimum conditions of infection or resistance and numerous other questions remain to be solved, but enough evidence has been collected to show that boll rots and the insects concerned in them are a very serious factor to be reckoned with by cotton-growers in Queensland. Not only is lint stained and weakened, and germination impaired, but the oil content of the seeds is also affected. A sample of 60 grammes of seed damaged by *Fusarium moniliforme* was sent to the British Australian Cotton Association Oil Mill at Whinstanes, and the manager, Mr. B. Cuthbert, very kindly had it tested for oil content against a sample of unaffected seed. The damaged seed was a fair mixed sample of severe and slight damage. Two lots of damaged seed of 10 grammes each and two lots of undamaged (10 grm.) were examined. They yielded for undamaged seed 18.3 per cent. oil, and for damaged 15.4 per cent. It is interesting to note that the average of these two gives almost exactly the normal percentage of oil extracted in the Mill from Queensland seed.

Until closer settlement takes place insect control must needs be difficult, but by no means impossible. *Tectacoris lineola* can be controlled by hand-picking, but the problem of *Dysdercus* and *Oxycarenus* remains to be solved, though from experiments made this year a solution is perhaps in sight.

Sufficient evidence is given in the preceeding pages to show that *T. lineola* is a very serious menace to the cotton industry in Queensland, through its connection with internal boll rots. All the commercially valuable products of the cotton plant are affected; colour, staple and strength of the lint is impaired; the germination of the seed is inhibited; and the oil content is lowered.

From the indications observed in the past season, it would seem that on the coast conditions approach the optimum for both *Tectacoris* and the fungi. The temperature and humidities are more uniformly high and rainfall is more evenly distributed, though even on the coast long spells of dry weather can be experienced.

The only economical remedy which so far presents itself is systematic hand-picking. The operation can be easily performed owing to the confiding nature of the insects. Only small individual areas of cotton are an economic possibility in Queensland, owing to the high cost of labour and machinery. On such small areas hand-picking can be done by the farmer and his family.

Parasites and Predators.

T. lineola is fairly well supplied with natural enemies. There are four egg-parasites* :—

Telenomus oecleus, Dodd, *Pachycrepis tectacoris*, Girault, *Eupelmus redini*, Girault, and *Ericydnus hemipterus*, Girault.

Of these *E. hemipterus* lays just before the *Tectacoris* eggs are due to hatch, taking some 13 days to emerge. This insect has two forms, one winged and the other with vestigial wings. Mr. Girault informs us that the fully winged variety has not before been seen.†

A small Blattid and a species of ant are suspected of preying on eggs and young nymphs, though further observations on this point are required. Nymphs suck the eggs of their own species.

Certain birds and a spider which has not yet been identified prey upon *Tectacoris* in the field. The spider was a great nuisance at Gatton, where it got into the cages and continually interfered with the life-history work, as it was not possible to keep these cages under constant supervision.

Estimates were made of the percentage of parasitism throughout the season. These covered the period from the middle of November 1924 to the end of April 1925

Date.	No. of egg-masses	No. of eggs	Percentage of parasitism.	Remarks
14 xi 24 ...	7	560	15	Egg-masses not numerous in the field. Middle of month, from eggs collected at Gatton.
12 xii 24 ...	3	253	91	
1-7 i 25 ...	14	1,540	25	Estimated from cages, as heat wave was in progress and eggs in field were either not parasitised or parasites failed to emerge.
ii 25 ...	-	-	40	
9 iv 25 ...	6	606	2.6	
15 iv 25 ...	7	741	0.3	
22 iv 25 ...	11	1,107	21	

All except the December count were made at Biloela. The heat wave apparently affected the parasites adversely.

* Kindly identified for me by Mr. Girault, Entomological Section, Department of Agriculture, Brisbane.

† Bred by F. G. Holdaway.

SUMMARY.

1. A general account is given of the habits and distribution of *Tectacoris lineola*, together with a description of the adult, and some remarks on the influence of weather conditions on mating.
2. The eggs and the different instars are described, and the period of time occupied by each is given.
3. The connection between *Tectacoris lineola* and boll rot incidence is established.
4. A table is given illustrating the comparative effect of boll rots and bollworm damage in the past season (1924–1925) on the Cotton Research Farm.
5. The effect of bug punctures on cotton seed and its infection with *Fusarium moniliforme* are briefly discussed.



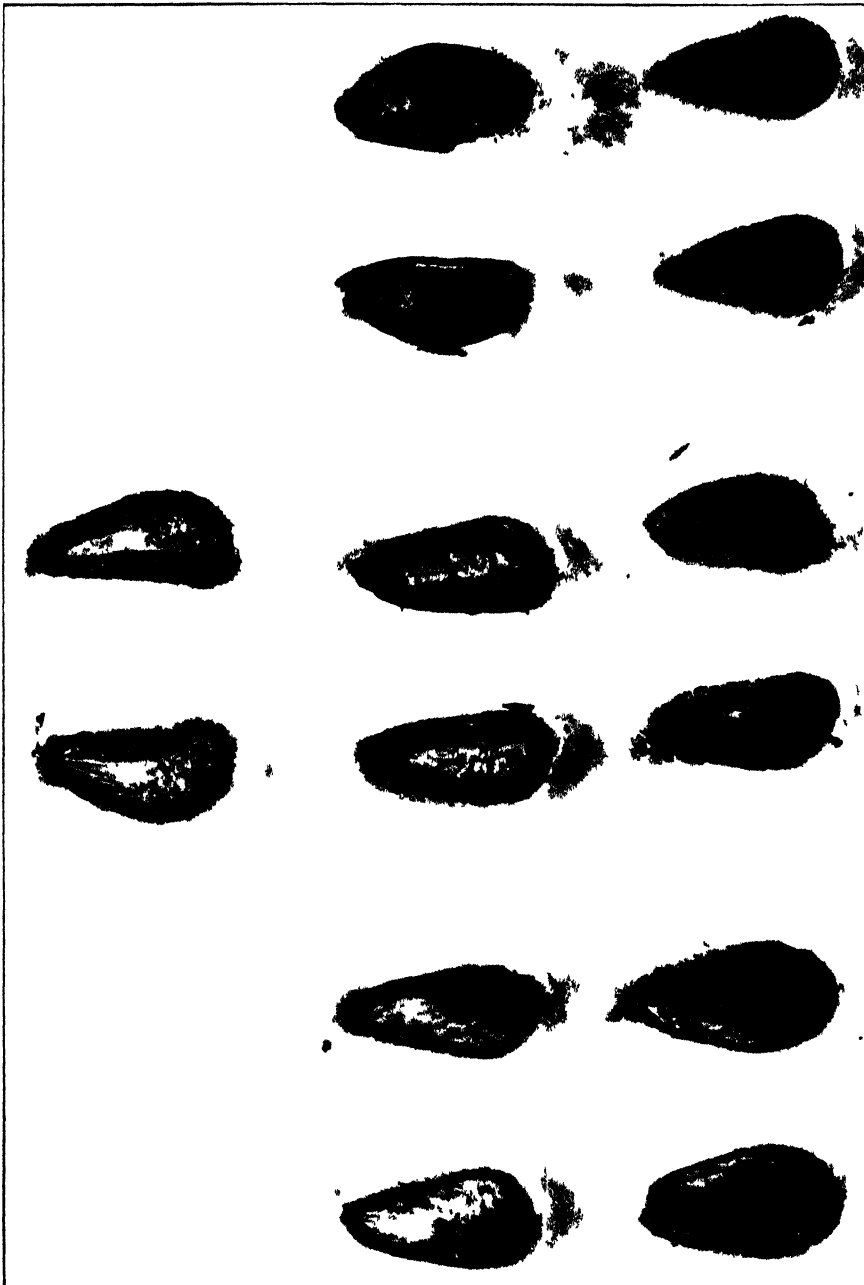
Fig 1 Cage used for rearing *Tectacoris*



Fig 2 Cages used in investigating the transmission of fungous disease by *Tectacoris*



On left cotton seeds from a normal lock on right seeds from
a lock that has been attacked by *Teetacoris*



Durango Cotton Seed two normal seeds (on left) and twelve seeds attacked by *Fusarium moniliforme* and associated bacteria as a result of insect punctures.

NOTES ON THE COFFEE BERRY-BORER (*STEPHANODERES HAMPEI*, FERR.) IN UGANDA.

By H. HARGREAVES,
Government Entomologist, Uganda.

The coffee berry-borer (*Stephanoderes hampei*, Ferr.) was first recorded as a pest in Uganda during the year 1908, and an account of the life-history was given by C. C. Gowdey in his report for the year 1909-10. There is very little doubt that the beetle is indigenous to this country and that its original food-plants were wild species of *Coffea*. The other parts of Africa in which it is known to occur are Tanganyika Territory, the Belgian Congo and French Gabun. It has also been accidentally introduced into Java, Sumatra and Brazil.

Since it was first noticed, the berry-borer has continued to be a pest, though the extent of its depredations has varied considerably. During some years the damage was small, while during others—particularly 1909, 1915 and 1921—the loss to planters was very serious. As a pest of coffee *Stephanoderes hampei* is almost as destructive as the bug, *Antestia lineaticollis*, Stål, and in some areas where the conditions do not favour *Antestia* the berry-borer is of prime importance.

The study of this coffee pest was commenced by the present writer in 1921 and has been continued at intervals. Although the following account is incomplete, it is thought that the information will be of use and of interest to coffee-growers.

Summary of the Life-history of the Borer.

Owing to the small size of the beetles and the consequent difficulty of controlling their movements under natural conditions the lengths of the various stages were determined in the laboratory.

For determination of the larval stage, newly-hatched larvae were placed in small cavities in coffee beans, after the pulp had been washed off the parchment, and kept in moist tubes. Whole, nearly-ripe berries were used for egg-laying and adult longevity determinations.

The fertile female bores into a half-grown, or more nearly mature, coffee berry through the fleshy pericarp into one of the beans. The entrance hole is circular and 1 mm. in diameter.

It feeds but little before laying the first eggs in the tunnel it has made within the bean. A period of five to thirty days elapses between emergence of the female from the pupa and deposition of the first eggs.

The egg hatches after eight or nine days, and the young larva commences to feed on the tissues of the coffee bean, producing a small gallery off the main tunnel made by the female. After about nineteen days the larva of the future female ceases to feed and remains quiescent at the end of its gallery; it then becomes a pupa. No cocoon is made. The larva of the future male feeds for fifteen days only before becoming full-grown.

The period spent in the pupal stage is from seven to eight days, after which the pupal skin splits and the adult beetle emerges.

Description of the Early Stages.

The egg is translucent white, 0.67 mm. long and 0.27 mm. at the middle, with one end more sharply rounded than the other.

The larva is a creamy-white footless grub with a pale brown head; hairs are sparsely scattered over the body and head. When full-grown the female larva is 2.25 mm. long and that of the male is considerably smaller.

The pupa is creamy-white at first and later becomes pale brown. That of the female is 2 mm. and the male 1.4 mm. in length.

Like the pupae, the adult male and female differ considerably in size, the former varying around 1.3 mm. while the female is approximately 1.9 mm. in length. When newly-emerged from the pupal stage, the beetle is pale brown and soft; the general colour gradually changes, becoming black after five days. The adult beetle (fig. 1) is subcylindrical, gently rounded anteriorly (prothorax) and more sharply rounded at the posterior extremity of the wing-covers; the head is small and subventrally inserted into the prothorax, and is consequently not always seen in the dorsal view of the beetle. The prothorax is dull black with minute pits and tubercles; the wing-covers are black and somewhat shiny in appearance, each with eleven slight longitudinal ridges clothed with linear series of regular hairs which alternate with the finer hairs of the minutely pitted furrows. The body, legs, wing-covers and antennae are clothed sparsely with fine, brown, short hairs. The short, clubbed and elbowed antennae and the legs are pale brown. The male resembles the female closely, except in size.

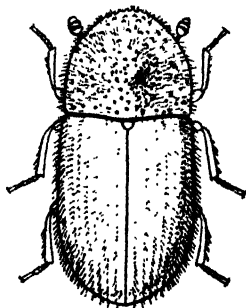


Fig. 1. *Stephanoderes hampei*, Ferrari.

Habits of the Adults.

The female beetle enters the berry almost invariably in or near the small depression at the tip, making a clean-cut circular hole. Unless the tissue of the bean is fairly mature and firm, the beetle abandons the berry and seeks more suitable food. Adults bred in one bean seldom attack the second bean of the berry until all the food of the first is exhausted, and it would appear that females do not migrate to other berries until scarcity of food compels them. Female beetles in considerable numbers have been observed in flight during late afternoon from infested "buni" coffee.

Fertilisation must take place in the berries where the males have been bred, because males seem incapable of flight and fertile females are never accompanied by males in newly-bored berries.

Females are far more numerous than males, the ratio being approximately ten to one, and the beetle must be polygamous.

Although eggs may be laid without previous fertilisation, such eggs do not hatch. The longest period during which a female produced eggs in the laboratory was eighty-three days, while the average period was forty-eight, and the shortest twenty days. The maximum number of eggs laid by a female was sixty-three, and the average thirty-one. As the method of obtaining data concerning egg-laying in the laboratory was liable to reduce considerably the rate at which eggs were laid, it is advisable to state that while one egg every two days was the general average, two eggs per day was the average for one female.

The average life of the female in captivity was ten weeks, the maximum being sixteen and the minimum five weeks. The male life was shorter than that of the female; the average was thirty-two days, the maximum being fifty-six and the minimum ten days. There must be at least eight broods a year; the generations overlap, and all stages of the pest may be found at any time.

There is no indication of any relation between prevalence of the beetle and particular weather conditions. Food is available throughout the year and there is no great variation of temperature, so that neither aestivation nor hibernation occurs.

Careful search in various districts has not revealed any plant other than coffee on which the insect feeds. The beetle attacks *Coffea robusta* and *C. arabica* with equal severity.

Nature of Damage.

Observations indicate that damage to coffee growing under shade is more extensive than is the case with unshaded coffee. It is the writer's opinion that this is due to preference by the parasites for a sunny habitat, and not, as might be inferred, to any preference by the beetle for shaded conditions.

The berry-borer directly damages the crop by feeding in the larval and adult stages on the tissues of the coffee bean. The whole of the bean may be destroyed or the bean may be so extensively damaged as to render it valueless. Coffee beans which show any evidence of borer attack are much reduced in market value.

Another type of damage due to the berry-borer is the production of rotten beans. When the female departs from a green berry into which it has bored, and which it has found unsatisfactory as food, a rot sets in, and the damaged bean decays. After pulping, such beans float in the wash tank; thus the berry-borer is responsible for the production of a proportion of "lights." When the borer infestation is extensive and comparatively few berries suitable as food are available, this type of damage becomes very serious.

It has been observed that the bean tissue lining the excavations made by the beetle becomes green after a short time. This discolouration, which was suggested some time ago as a possible cause of "grassiness" in Uganda coffee, has, according to Leefmans* in Java, been proved to be due to chlorogen acid.

Stephanoderes hampei is of major importance to coffee-growers in Uganda. In view of the fact that the insect occurs in all the main coffee-growing areas, the resulting total damage over a series of years must nearly equal that done by the coffee-bug. During severe infestations, which seem to be periodic in their occurrence, as many as eighty per cent. of the coffee berries on a particular estate may show evidence of borer attack. It must be noted that the degree of borer infestation at a particular time may vary greatly in different coffee-growing areas.

In Java, where the berry-borer was first noticed in 1909 and where no insect parasite has been found, the depredations of the beetles have been so severe in some areas that coffee culture has been abandoned.

* Leefmans, S. De Koffiebessenboek.—Meded. Inst. Plantenziekten, No. 57 (1923).

Natural Control.

1. Until 1921 it was not known that the berry-borer in Uganda was attacked by parasites. It was then that the writer's attention was drawn by a planter to some small Hymenoptera which he had reared from berries damaged by *S. hampei*. The possibility of utilising the parasites for the control of the beetle led to a study of the subject.

Material obtained at that period from the Government Plantation, Kampala, showed that a small parasite of the berry-borer was fairly common in "buni" (over-ripe and dried) berries. The following facts relating to this parasite (as yet unnamed) were obtained in 1921; it has not been possible to supplement the information because this species was not found during subsequent investigations.

The parasite lays eggs singly on full-grown larvae and newly-transformed pupae that would have produced female beetles. The egg is minute, elongated and of the same colour as the host; it is attached lengthwise, usually to the ventral surface of the thorax. The host was not observed to be stung by the female prior to oviposition. When hatched out, the parasite larva feeds externally on the host, and when it is full-fed only the skin of the host remains. Pupation takes place in a delicate white silk cocoon, usually attached to the skin of the coffee bean or occasionally among the remnants of the tissues. The pupal period is seven days and the total length of the immature stages—eggs, larva, and pupa—is from twenty-five to twenty-eight days. Adult parasites lived in captivity for fifteen days without having taken any food. The observations indicated that the adult parasite feeds on the immature stages of the beetle.

The maximum number of parasites reared from a single berry was twenty-six, and berries containing the largest numbers of parasites were in the "buni" condition.

This parasite was able to pass through wire gauze of forty to forty-four strands to the inch, whereas the beetle was unable to do so. In view of this fact it was possible to rear and allow only the parasites to escape from cages containing borer infested "buni" coffee. As mentioned above, the presence of this species of parasite has not been observed since 1921, and as the two later discovered species are larger and of different habits, it is not possible to utilise them in the above manner.

2. *Prorops nasuta*, Waterst., another parasite of the berry-borer discovered early in 1923, is of very great importance. During April 1923 this species was present in small numbers on the Government Plantation, Kampala; three months later the borer was so extensively parasitised that only eggs, small larvae, and adult beetles could be found, and the investigation of the parasite had temporarily to be abandoned.

Below is an account of the details thus far obtained concerning *P. nasuta* :—

The egg is laid singly, usually on the ventral surface of the thorax of a full-grown beetle larva. After three days the parasite larva hatches out and, remaining attached to the host, feeds externally. The larval stage is of short duration, usually three, but sometimes four days. When the parasite is full-grown and only the skin of the host remains, a white silk cocoon is spun in the bored berry, and the parasite transforms to the pupal condition.

This stage averages twenty-one days in duration, after which the parasite, now adult, bites a hole in the cocoon and emerges. The total period from the deposition of the egg to the emergence of the adult varies between twenty-four and thirty-two days, the average being twenty-seven.

The female feeds on small borer larvae, which it first stings, sucking out the body contents. It would seem that the female, after emergence, seeks a borer-infested

berry and spends most of its life there, feeding on immature beetle stages and laying eggs on full-grown host larvae as they become available.

After stinging its victim in several places through the ventral surface the female attaches an egg to the beetle larva. Host larvae which have been stung remain alive for a long time, but are unable to move, and thus living food in a defenceless condition is available for the parasite larva when it hatches from the egg.

The pre-oviposition period averages seventeen days. Parthenogenesis is common ; eggs laid by unfertilised females usually hatch and develop normally. In all cases the adults reared from unfertilised eggs were males. Some females, however, seemed incapable of parthenogenetic reproduction. The maximum number of eggs laid by a female in captivity was thirty-seven. The rate of egg-laying varied between two a day and one every two days.

The longest period for which a female lived in captivity was sixty-five days, while the average period was forty-seven.

The adult (fig. 2) is approximately 2.3 mm. in length, exclusive of the antennae. The head and body are dark brown, almost black, while the antennae and legs are of pale brown colour. The antennae are short and twelve-jointed. The jaws are strongly developed ; a short median snout-like projection is present above the jaws. The female has a short extrusible ovipositor.

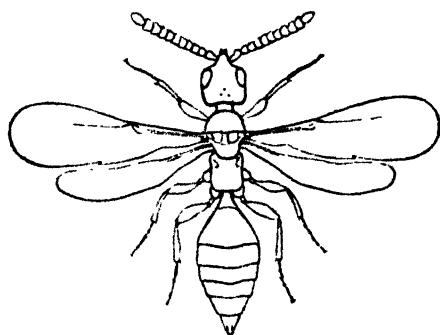


FIG. 2. *Prorops nasuta* Waterst

The egg is comparatively large (0.53 mm. by 0.18 mm.), elongated, sausage-shaped, translucent, and of the same colour as the host, thus rendering detection of the egg rather difficult, although its size enables it to be seen by the unaided eye. The surface is granular and reticulated. The hatching of the egg is indicated by its shining appearance and very faint segmentation.

The larva is translucent, white, faintly segmented and devoid of hairs. The full-grown larva is 1.8 mm. long and 0.65 mm. at its greatest breadth ; the head extremity is blunt, and the body tapers toward the pointed anal extremity.

The pupa is at first white and gradually becomes dark brown as metamorphosis proceeds.

3. *Heterospilus coffeicola*, Schmiedeknecht (fig. 3) is a third species parasitic on *S. hampei*. It was first noticed in May 1923 gradually replacing *P. nasuta* and later continuing to hold the berry-borer in check.

It has not been found possible to breed this parasite in captivity, and facts relating to it are consequently meagre.

The adult of this species, in contrast to those of the other parasites, appears to spend little time within the borer-infested berry. In no instance has more than one

egg of *H. coffeicola* been found in one coffee berry. The egg is minute (0.385 mm. by 0.13 mm.) and owing to the colour resembling that of the borer egg, careful search aided by a lens is necessary to detect the parasite egg. The egg is laid, possibly through the bore hole, usually on a group of borer eggs in a recently infested berry. After hatching out, the larva feeds on eggs and all sizes of larvae of the berry-borer, and during its larval period of eighteen or twenty days disposes of some fifteen eggs and larvae. The full-grown larva is approximately 1.8 mm. long and 0.63 mm. at its thickest part; it is translucent, white, with sparse minute hairs and paired, segmental, well-developed prominences, which serve to distinguish the larva from that of *P. nasuta*. A white silk cocoon is spun for pupation within the berry, usually at the entrance to the bean. The pupal stage is of considerably shorter duration than the larval stage. The adult female is 2.5 mm. long exclusive of antennae and ovipositor, which are respectively 2.5 mm. and 0.6 mm. in length. The total length is 5.6 mm.—about one-fifth of an inch. The body and the antennae, except the segments near the base, are dark brown, almost black, while the legs, ovipositor, and the first four antennal segments are pale brown. The male differs in appearance from the female in having no ovipositor and in possessing a stigma (a small dark area) near the base of each hind wing.

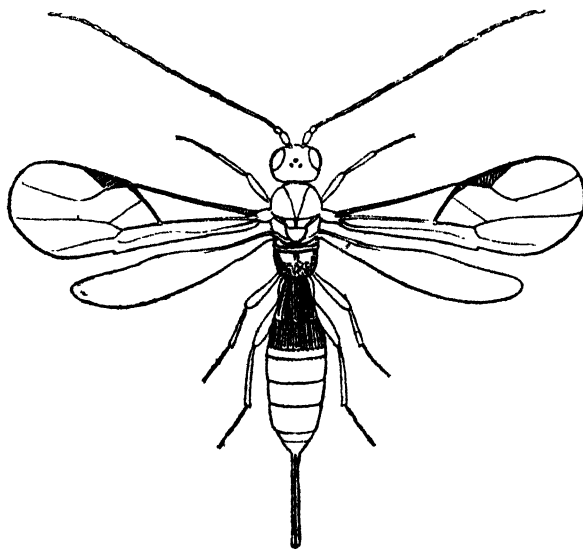


Fig. 3. *Heterospilus coffeicola*, Schmied.

In view of the free-living habit of the adult and of the large number of immature stages of the beetles consumed by the parasite larva, it is probable that *H. coffeicola* is of the greatest importance among the three species of parasites as a check on the increase of the berry-borer.

4. It has been noticed that dead beetles found in bored berries are often covered with the mycelium of a fungus. In such cases the entrance to the bore is frequently blocked with the white mycelium. Examination by the Government Mycologist proved the fungus to be a common saprophyte and not one of the group of fungi which are parasitic on insects. Therefore it would appear that the beetles had died natural deaths.

Artificial Control.

It must be stated at the outset that no satisfactory method of controlling the berry-borer has yet been discovered. In this section it is proposed to discuss some aspects of the problem.

1. The late Entomologist, Mr. C. C. Gowdey, tested the efficiency of lead arsenate and lead chromate as controls for berry-borer. After removal of infested berries, rows of trees were sprayed and one row left unsprayed for comparison; the numbers of bored berries on sprayed and unsprayed trees were compared after an interval of two months. The results showed a certain reduction in the infestation of the sprayed trees, but the experiment was not continued over a sufficiently long period to obtain a fair idea of the benefits which might be expected from spraying.

In Uganda, large scale spraying is not practicable owing to high cost of insecticides and spraying appliances and to the unsuitable type of labour available. In consideration of this fact no further experiments have been undertaken on this line of control.

2. A method of chemical control that might successfully be employed, were it not so expensive, is the fumigation of infested trees by means of hydrocyanic acid gas and tent-like covers. This is commercially practised in other countries for the control of certain insects on fruit trees.

3. Another method of control, which is applicable in certain circumstances and which has proved successful in a few instances, consists of picking and destroying, by burial or other means, the smaller crop maturing in April. This, of course involves total loss of the small crop together with the cost of picking. Such expense is warranted only in cases where the infestation is very severe and parasites are so rare as to render retention of the crop a grave danger to the succeeding larger crop.

No general recommendation for taking such drastic action can be made; each case must be thoroughly examined to determine the extent of the infestation of the berries and the degree of parasitisation of the borer. Account must also be taken of the fact that the berries on some sections of an estate may be comparatively free from the borer while other sections may be heavily infested.

4. Observations on the Government Plantation, Kampala, extending over a number of years, indicate that conditions there are unfavourable to severe infestation of coffee by *S. hampei*. The only unusual factor in conspicuous evidence there is the growing of *robusta* coffee on plots in close proximity to plots of *arabica*. This seems to indicate that *robusta* coffee, which carries a certain amount of maturing berries throughout the year, has a decidedly beneficial influence on the prevalence of the parasites of the berry-borer.

Continuous presence of maturing berries is likely to provide for continued breeding of the beetle, but it must also be remembered that it will ensure the presence of the parasites. The harvesting of ripe coffee berries involves the elimination of a greater percentage of parasites than of beetles and thus tends to increase the borer infestation; this is supported by the fact that severe borer infestation of the following crop usually occurs after an abnormally large crop, showing little evidence of borer attack, has been picked. The beetles usually survive pulping of the coffee and escape from the beans while they are drying in the trays, whereas the immature stages of both the beetle and its parasites probably die during the exposure of the beans to the sun in the drying trays.

When the whole of a crop of *arabica* coffee has been picked, little of the next crop has reached the stage in which appreciable numbers of parasites can find suitable host material on which to lay eggs, and breeding of the parasites is consequently retarded. In this manner the removal of a coffee crop tends to upset the balance of the complex relationship between the borer and its parasites, and anything which

can be done to counteract this adverse effect, by an approach toward natural conditions or by other means not inimical to the production of large crops, will tend to eliminate the severe outbreaks of berry-borer, which under present conditions are certain to occur periodically. In this connection it is of interest to note the condition of coffee estates which had been abandoned for some time and from which crops had not been picked. In such cases, where a small crop was on the trees and a partial reversion to wild conditions had occurred, borer infestation was negligible.

In order to test the above theory of the beneficial influence of growing *robusta* among *arabica* coffee it has been arranged that the projected experimental plot of *arabica* coffee near Masaka shall be interplanted with *robusta* trees. The arrangement will be: one *robusta* to seven *arabica* trees in every eighth line, i.e. one *robusta* to sixty-four *arabica* trees, which is approximately 1.6 per cent. The crop on the *robusta* trees will not be picked but will be allowed to dry and fall in the natural manner. This experiment must be under observation for several years before reliable conclusions can be reached.

CERATOPOGONINAE FROM DAR-ES-SALAAM.

By J. W. S. MACFIE.

The following note records the CERATOPOGONINAE found in two collections of small insects made by Dr. J. F. Corson at Dar-es-Salaam, Tanganyika Territory, East Africa, 1st to 20th September 1925. All the insects were taken between 5.30 p.m. and 6.30 p.m. on the windows of either the Bacteriological Laboratory or of a bungalow. We have pleasure in dedicating to the collector the single new species found.

Forcipomyia corsoni, sp. n.

Length of body,* 1.3 mm., length of wing, 0.8 mm., greatest breadth of wing, 0.3 mm. In the male the body is slightly longer and the wing narrower than in the female.

Head dark brown. Eyes bare, the facets narrowly separated in both sexes. Clypeus and proboscis brown; the clypeus bears about nine hairs. Palpi pale brown; the approximate lengths of the four terminal segments (2 to 5) were 8:15:10:7 units† in the female, and 7:13:9:5 units in one male. The third segment is somewhat inflated proximally and bears in the female a small sensory pit, and in the male a shallow depression from which arise the sensory hairs. Fifth segment rounded at its end, and, especially in the male, broadly united with the fourth.

Antennae. In the female first segment brown, bearing about a dozen dark brown hairs. Torus sub-spherical, dark brown, bearing a few short hairs. Flagellum segments uniformly brown; whorls composed of about 12 hairs, and segments 4 to 10 armed with long, colourless, tapering spines. Segments 4 to 13 moderately long, not compressed, slightly constricted apically, forming an almost continuous series, the proportion of length to greatest breadth ranging from 8:6 to 10:6 units. The fourteenth segment (9 units) is slightly shorter, and the fifteenth (11 units) slightly longer than the thirteenth; the fifteenth segment is also rather broader, and terminates in a nipple-like process or stylet about 2 units long. The combined length of segments 11 to 15 (52 units, including stylet) less than that of segments 3 to 10 (67 units), or 4 to 10 (58 units). In the male, torus large and dark brown, flagellum segments rather pale brown with whorls of brown hairs. Segments 4 to 11 gradually narrowing, measuring in length and greatest breadth in one specimen from 9:8 to 9:4.5 units. Segments 12 to 14 elongated, not binodose, their lengths in the same specimen being 22, 15, and 11 units respectively; the last segment stouter, about 12 units long, ending in a short stylet about 1.5 units long. The combined length of segments 12 to 15 (62 units, including stylet) less than that of segments 3 to 11 (80 units).

Thorax uniformly dark brown dorsally, well clothed with dark brown hairs which are rather short; pleura rather paler. Scutellum darkish brown; bearing in the single female examined a transverse row of ten bristles and eight small hairs, and in the male two lateral and six centro-marginal bristles and twelve small hairs. Post scutellum dark brown.

* This measurement is taken from the anterior margin of the thorax to the tip of the abdomen of specimens mounted in pure carbolic acid.

† The unit referred to is 3.7 μ .

Wings unadorned, moderately well clothed with hairs some of which, in the female, are slightly flattened; without scales. Microtrichia minute. Fringe well developed, hairs apparently simple. Costa reaching slightly beyond the middle of the wing in the male (24 : 45), and a little short of the middle of the wing in the female (21 : 48). First and third veins fused or nearly fused proximally, but forming a small triangular, distal cell. Bifurcation of the fifth vein distal to the level of the end of the costa in both sexes, but more notably so in the female. Halteres infuscated, with dull white knobs.

Legs uniformly pale brown, unarmed, without scales but with some of the hairs (on the terminal tarsal segments, for example) slightly flattened. First tarsal segment much longer than the second on all the legs in both sexes; on the hind legs about twice as long in the female, and two and a half times as long in the male. Claws long, slender, curved. Empodium long, narrow, hairy.

Abdomen darkish brown, without characteristic markings, well clothed with hairs, without scales. Spermatheca single, highly chitinated, rather retort-shaped, total length about 56 μ .

Hypopygium (fig. 1). Ninth segment long; tergite well clothed with rather short hairs, its posterior margin rounded, the lateral finger-like processes feebly developed; sternite deeply excavated in the middle line posteriorly, and bearing ventrally two transverse rows of hairs. Forceps well developed, claspers highly

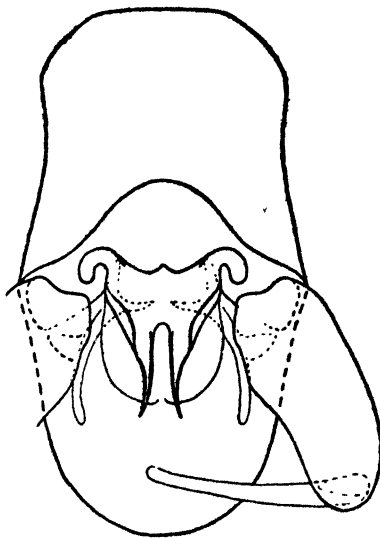


Fig. 1. Hypopygium of *Forcipomyia corsoni*, sp. n. $\times 365$.

chitinated, slender, hairy at the base. Harpes somewhat resembling those of *F. murina* (Winn.) as figured by Saunders, each with a long, posteriorly projecting plate. Aedoeagus densely chitinated at the base, especially laterally, where it is extended as strong recurved roots, and prolonged posteriorly into two sharply-pointed processes. Membrane joining the aedoeagus to the ninth sternite devoid of spicules.

TANGANYIKA : Dar-es-Salaam, September 1925, 1♀, 4♂♂, taken in the evening on the windows of the laboratory (Dr. J. F. Corson).

This insect bears resemblances to species of the genera *Apelma* and *Thyridomyia*, and the form of the harpes of the male is similar to that of *Forcipomyia murina* (Winn.) as figured by Saunders (1925). As in the case of *F. murina* according to

Saunders, so in this instance, the species cannot be included in the genus *Apelma* on account of the empodium which is present in the male, and the elongated form of the basal segments of the flagellum of the antenna of the female precludes its admission into either *Apelma* or *Thyridomyia*. The species, together with *F. murina*, should probably be included in a new genus. Saunders has postponed erecting a new genus for *F. murina* pending the discovery of the immature forms which should assist classification, and therefore it will be best to leave this East African species temporarily in the genus *Forcipomyia*.

***Forcipomyia biannulata*, I. & M.**

1♂, taken in Laboratory, 2♀♀, taken in bungalow.

***Forcipomyia lepidota*, I. & M.**

3♂♂, 1♀, taken in bungalow.

***Forcipomyia murina* (Winn).**

1♂, taken in bungalow.

***Culicoides austeni*, C. I. & M.**

1♂, taken in bungalow.

***Culicoides bedfordi*, I. & M.**

1♀, taken in bungalow. This insect resembles *C. bedfordi*, and the spermathecae are of the form characteristic of that species. The adornment of the wing is, however, somewhat different. The wing, which is brownish, especially over the radial areas, is rather sparsely clothed with macrotrichia, only a single row extending towards the base between the fourth and fifth veins. The pale spot immediately distal to the end of the costa is small but distinct. The larger pale area, which in *C. bedfordi* envelops the cross-vein and reaches forwards to the costal border, is, however, almost obsolete, represented only by an indistinct pale area immediately distal to the cross-vein. As in *C. bedfordi*, there are but faint indications of the peripheral pale spots. Notwithstanding these differences, the insect is probably *C. bedfordi* in our opinion, but the identification requires confirmation by the examination of further specimens, especially males.

***Culicoides distinctipennis*, Aust.**

2♀♀, taken in bungalow.

***Culicoides pycnostictus*, I. & M.**

1♀, taken in bungalow. The pale areas on the wings of this specimen are more extensive than in the co-types, but are recognisably the same. In particular the pale areas on the anterior half of the wing are large, diffuse, and tend to become confluent.

***Culicoides schultzei* (End.).**

7♂♂, 6♀♀, taken in laboratory; 1♂, 4♀♀, taken in bungalow.

***Culicoides similis*, C. I. & M.**

2♀♀, taken in bungalow.

***Dasyhelea flava*, C. I. & M.**

8♀♀, taken in laboratory; 1♂, taken in bungalow.

***Dasyhelea inconspicua*, C. I. & M.**

1♂, 1♀, taken in laboratory.

A NOTE ON THE BIONOMICS OF *TABANUS FASCIATUS NILOTICUS*, AUST.

By HAROLD H. KING, F.L.S., F.E.S.,
Government Entomologist, Wellcome Tropical Research Laboratories, Sudan.

A few larvae of *Tabanus fasciatus niloticus* were obtained on 4th March 1925 near Renk, on the White Nile, their habitat being the Nile cabbage (*Pistia stratiotes*, Linn.). They were by no means common, a search of a couple of hours yielding but seven specimens. They were lying submerged in the water, supported on the bases of the lower leaves in such a position that their caudal respiratory siphons could be extended to reach the surface of the water, and never more than a single larva occurred on an individual plant. In appearance they were typical Tabanid larvae, except as regards colour; the normal colour is white to yellowish, but the larvae in question were bright green, similar to the green of the leaves among which they were situated. They were placed in a glass jar with water, plant débris and some Nile cabbages, and taken to Khartoum, the journey occupying ten days. When the contents of the jar were examined in Khartoum two larvae were recovered and removed each to a test-tube containing a roll of filter-paper and water. They fed readily on earthworms.

On the 17th April the larger of the two larvae showed signs of readiness to pupate. By the following day it had pupated and was lying between the layers of filter paper in a more or less vertical position. In colour it was green, but duller than had been the larva. It differed from any Tabanid pupa that I had previously either bred or seen described, in the possession of a pair of thoracic respiratory siphons, conspicuous for their pale brown colour, and very similar in general appearance to the respiratory siphons of Culicine pupae. That they functioned as respiratory siphons appears to be certain; for if the pupa were entirely submerged by adding water to the test tube, it would within a minute become restless and commence to work its way up by writhing movements until the tips of the siphons reached the surface of the water, when it would again become quiescent. It was unable to rise to the surface unless it could support itself by means of the rings of spines on the abdominal segments, against some object such as the filter paper. On 26th April it was seen to work its way up until only the caudal aster remained in the water, when the split occurred on the dorsum of the thorax and the fly—a female—emerged. The act of emergence occupied approximately 90 seconds.

When newly emerged the head, thorax and legs were of the normal colour of the species, but the abdomen was bright green and the wings clear pale green. By the following morning the abdomen had acquired the normal colour, and the green had disappeared from the wings, which had developed the characteristic dark markings.

The usual habitat of Tabanid pupae is damp sand or earth, though sometimes during the dry season the medium in which they are living may become dry, apparently without their being adversely affected. Under such conditions they neither require nor possess respiratory siphons. The pupa of *T. kingi*, Aust., has been found under a stone in running water, but though, in such a situation, it might be thought to require respiratory siphons, it does not possess them. In the pupa of *T. fasciatus niloticus* the abdominal stigmata appear to be normally developed, and possibly would function if the pupa were removed from water, but as the identity of the specimen was uncertain until the adult emerged, no attempt was made to determine this point.

A NEW SPECIES OF *TRIPHLEPS* (HETEROPTERA, ANTHOCORIDAE)
PREYING ON THE EGGS OF *HELIOTHIS OBSOLETA*, H.S.,
IN QUEENSLAND.

By W. E. CHINA.

A new species of *Triphleps* has been received by the Imperial Bureau of Entomology from Mr. E. Ballard, who reports it as attacking the eggs of *Heliothis obsoleta*, H.S., in Queensland. Although there are already forty-four species of *Triphleps* described from all parts of the world, this is the first species to be recorded from Australia. Garman & Jewett have previously (1914) reported *Triphleps insidiosus*, Say, as feeding on the eggs of *H. obsoleta*, H.S., in the United States.

***Triphleps australis*, sp. nov. (fig. 1).**

♀. Elongate, oval, shining, almost glabrous. Black, the hemelytra pale yellowish-brown, with the clavus, the embolium and the cuneus more or less ferruginous brown; legs yellow. Length (incl. membrane) 1.75 mm., breadth at base of pronotum 0.69 mm.

Head with the eyes distinctly broader than long, shining black, the juga finely punctate, the punctures extending on to the vertex in the form of a V-shaped group as far as the ocelli; the base of the vertex behind the ocelli finely wrinkled; eyes dark red, ocelli yellowish brown; labrum pale yellow, rostrum extending to anterior coxae, ferruginous brown, the apical half of the second joint and the basal half of the third joint yellow; antennae moderately thin, pale yellow, covered with moderately long pale hairs, the basal joint, the apical half of the third and the fourth joint infuscate; length of joints from the first, 0.093, 0.203, 0.156 and 0.179 mm., the second joint slightly longer than the width of the vertex between the eyes.

Pronotum shining black, strongly and distinctly punctate on the posterior half, the punctures provided with a very short erect bristle-like hair, anteriorly more finely punctate; disc feebly convex, strongly depressed behind the smooth shining calli; lateral margins almost straight and more or less distinctly carinate but anteriorly narrowed and rounded; posterior margin broadly emarginate, more than twice as wide as the anterior margin, which is as wide as the pronotum is long in the middle.

Scutellum shining black, obscurely rugosely punctate with scattered very short depressed hairs; disc slightly depressed.

Hemelytra distinctly but not strongly punctate, the punctures provided with very short depressed hairs; pale shining yellowish brown, the clavus, embolium and cuneus infuscate, the apex of the embolium and the outer and apical half of the cuneus dark, shining ferruginous brown; membrane opaque whitish, with three rather obscure longitudinal veins. *Wings* white, opaque, the hamus of the discal cell distinctly remote from the origin of the vena decurrens.

Sternum shining black, more or less finely rugosely wrinkled.

Venter shining black, shading to dark ferruginous brown on the genital plates; each ventrite laterally with a transverse punctured band across the middle, the punctures provided with very short depressed pale hairs; genital plates also sparsely clothed with short pale hairs; at the apex of the abdomen a long dark-hair projecting on each side of the ovipositor.

Legs yellow, the apical halves of the last joints of the tarsi and the claws more or less fuscous; some specimens with the hind femora in the middle faintly shaded with brown; tibiae covered with moderately short pale hairs and fine bristles.

QUEENSLAND: 5 ♀♀, "attacking eggs of *H. obsoleta*" (E. Ballard).

Similar in general form to *T. insidiosus*, Say, but differs in having the hamus of the discal cell remote from, instead of in line with, the origin of the vena decurrens; in the less convex and more distinctly punctate pronotum; in the pale yellow legs; and in the absence of the darker patch at the base of the clavus.

T. australis comes nearest to *T. puncticollis*, Poppius (1909), described from Ceylon, but differs in the shorter pilosity and in the shape of the pronotum, the base of which is more than twice as wide as the anterior margin, instead of only one-half wider as it is in *T. puncticollis*.

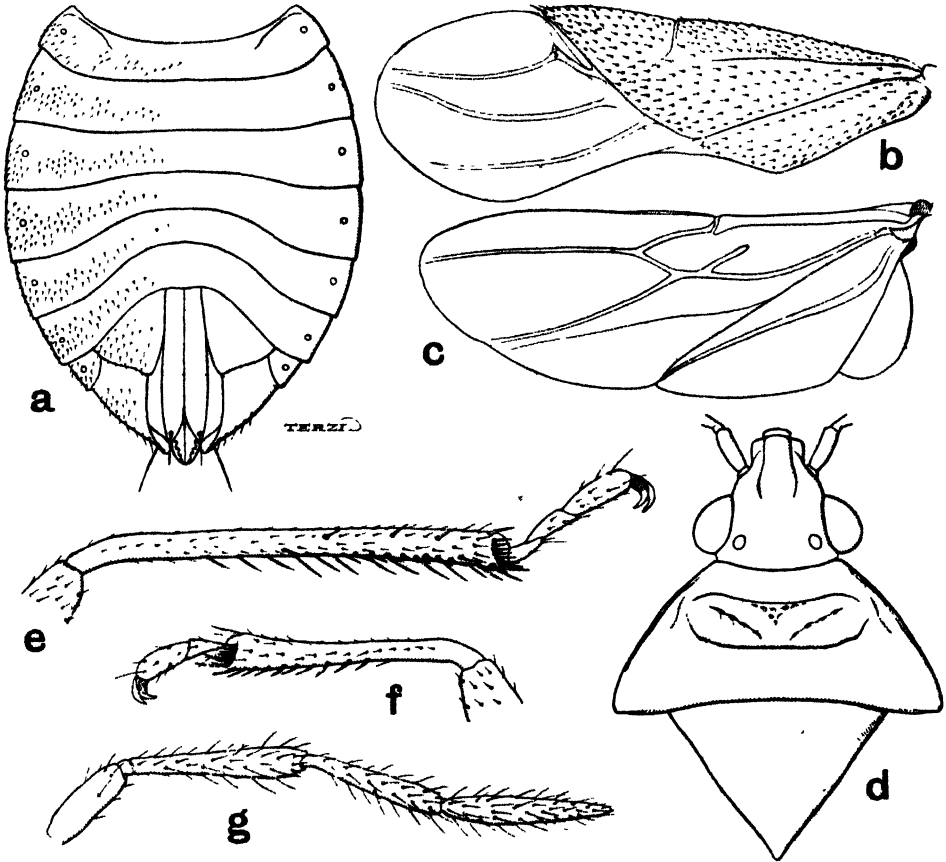


Fig. 1. *Triphleps australis*, sp. nov.: a, ventral view of abdomen; b, hemelytron, c, wing; d, dorsal view of head, pronotum and scutellum (puncturation omitted); e, hind tibia and tarsus; f, front tibia and tarsus; g, antenna.

THE INFLUENCE OF TEMPERATURE ON THE MATURATION AND GENERAL HEALTH OF *LOCUSTA MIGRATORIA*, L.

By V. P. POSPELOV.

State Institute of Experimental Agronomy, Leningrad.

(PLATES XVII-XIX.)

These experiments with *Locusta migratoria* show that temperature conditions during breeding have a great influence on the normal development and general health of this insect. There is a certain limit of favourable temperature, below which the development of the genital products in the imagines ceases, and the insects easily succumb to bacterial diseases.

The breeding experiments were carried out in cubical wooden cages with glass walls measuring 0.5 metre each way. The cages were warmed by electric lamps, and the necessary moisture was produced by water evaporation. In each cage were placed 20-30 young larvae of *Locusta migratoria* immediately after they hatched from the egg.

In the first experiment (5th April to 29th June 1924) the temperature inside the cages was maintained at 35°-38°C. (95°-100°F.), and the humidity was maintained nearly at saturation point. In these conditions the development of the insects was very rapid. On 20th May the first imagines appeared, and on 29th June they were already laying eggs. The larvae had the typical features of the migratoid phase, and the imagines were all of the *migratoria* phase (Uvarov¹¹).

In the second experiment, begun on 9th May, the larvae during their first two instars were kept under the same conditions of temperature and moisture as in the first experiment. When in the 3rd instar they were transferred into a lower temperature, which fluctuated between about 30°C. (86°F.) by day and 20°C. (68°F.) during the night. The humidity was about 70 per cent. The larvae under these conditions developed slowly. They became sluggish and ate little. Some died during their moults; others transformed into imagines after remaining in the alternating temperature for 46 days. The duration of development in the second experiment was 30 days longer than in the first experiment. But most remarkable was the influence of low temperature upon the maturation of the imagines, which when kept in the alternating temperature (20°-30°C.) could not mature and died without laying their eggs.

It is interesting that the influence of the low temperature was followed by immaturity in the imagines not only in the locusts bred in artificial conditions, but also in individuals collected in nature near the River Kuban and transported to Leningrad. The ovaries and testicles of the locusts during the first few days after the final moult were invariably in an immature condition, whether they were reared in a high temperature or in the alternating temperatures, or under entirely natural conditions. The ovaries of the females in that period are about 8 mm. long and consist of egg tubes with hardly distinguishable egg-chambers (Pl. xviii, fig. 1). The testicles of the males are only 7 mm. long and are wrapped round with the tracheal ring, with which the symmetrically arranged abdominal tracheal sacs communicate (Pl. xvii, fig. 3). The accessory glands of the males at this period are empty, curled and wrapped round with tracheae (Pl. xvii, fig. 4). The fat-body is pierced by the tracheal branches and covers in a net-like envelope the tracheal sacs and tracheal branches that occupy the body cavity between the intestine and the heart.

The behaviour and the development of the genital products of the locusts varied according to the temperature in which they were kept. In the cage with a temperature of 35°C. (95°F.) the locusts were very active, often flew up and ate readily. At night their chirping might be heard. After a month the locusts begun to copulate and ten days later they laid their eggs.

In the cage at room temperature (experiment in 1925) the locusts were sluggish, ate little and remained sexually immature from June till September, when they died. In the experiment in 1924 the imagines of the locusts died at room temperature from a bacterial disease after one month. The experiment in the cage at room temperature in 1924 was continued with the progeny of locusts obtained from the North Caucasus on 10th August. These individuals had the genital products still little developed. Placed in the cage at room temperature, which in September during the nights fell to 20°C (68°F.), the locusts lived till October, but could not attain maturity, though the eggs in their ovaries became more developed. In various parts of the body, particularly in the fat-body and the pericardial cells, were observed some red-coloured granules, probably containing urates.

In nature the imagines of locusts also matured but slowly. In the North Caucasus in September 1924 there were many cases of locust swarms flying from their breeding-places in the valleys of the Rivers Kuma and Terek to the steppes and cultivated areas of the Government of Terek, Stavropol and the Gorsky district, and the Dagestan Republic. The locusts that remained in the cornfields and fed on the corn were mature, the testicles and ovaries being well developed, the air-sacs reduced, and the fat-body filled with drops of yellowish fat. Compared with the results of the breeding experiments, the development of the locusts in nature after the period of flying was in the same stage as that reached by the locusts that had been reared at a high temperature for a month (Pl. xix). The influence of high temperature was replaced in nature by the physiological action of the efforts of the insects in flying, the consequent increased oxidation resulting in a rise of temperature.

The period of immaturity from the emergence of imagines till their maturation has some analogy with the imaginal diapause, that was described by me (1911) in certain groups of Lepidoptera and other insects.⁹ In such Lepidoptera, for instance *Vanessa polychloros*, the period of the imaginal diapause is continued during the summer, autumn and winter till the warm days of the next spring, when the butterflies are awakened from their long rest and begin to feed on the nectar of flowers. The genital products, which remain immature during the whole period of rest, only then begin to develop. The fat-body, which during the whole period of diapause is overdeveloped, interlaced with tracheal branches and filled with reserve materials in the form of yeast-like granules, begins to liquefy and to serve as food for the developing genital products. In the same way, during the period after the final moult and till flying, the imagines remain immature and have the fat-body much developed and interlaced with tracheal branches and tracheal sacs.

The cause of the temporary stoppage in the development of the genital products and the reserve stage of the fat-body is still uncertain. Several hypotheses have been proposed to explain the diapause in insects. According to Roubaud⁷ the cause of the diapause in the pupae of flies is the accumulation of urates in the fat-body and Malpighian tubes. The urates provoke an intoxication of the organism, manifesting itself in the retardation of the vital processes (asthenia), which results in the beginning of the rest period (diapause). During the diapause the urates are excreted from the organism, which becomes reactivated. Roubaud regards as urates the basophil granules (pseudonuclei according to Berlese) that fill the cells of the fat-body at the beginning of the puparium stage.

In my paper¹⁰ "The sterility of butterflies and an attempt to interpret it" I also connected the diapause in Lepidoptera with the accumulation in their fat-cells

of granules resembling pseudonuclei, but I think that these granules are some yeast-like symbiotic micro-organisms, which multiply in the fat-cells and accumulate the reserve products and urates. After the period of diapause these micro-organisms lose their vitality, are dissolved and serve as food for the developing genital glands and other imaginal tissues.

The fat-body of locusts in the first instar of the larval stage is white and filled with granules resembling cocci. In the centre of the fat-cell is placed the nucleus, round which the protoplasm is accumulated with the branches directed radially to the periphery of the cell. The granules are accumulated in these radial branches of the protoplasm. In the last larval instar and during the first days of the imaginal stage the fat-body becomes yellowish, between the branches of the cell-protoplasm appear large drops of yellow liquid fat, and the quantity of the granules in the fat-cells is diminished. In some lobes of the fat-body not only the granules, but partly also the nuclei become dissolved, and beneath the membrane of the fat-lobe appear empty spaces, covered with one layer of cells and communicating with air sacs. The condition of the fat-body differs according to the degree of development of the genital products.

When the locusts are being reared in a high temperature (35–38°C.), their air sacs on the 3rd to 4th day collapse (Pl. xviii, fig. 2), and are covered with the lobes of the yellow fat-body, in the cells of which the granules are replaced by large drops of the liquid fat. Locusts in nature after migration present the same appearance in the fat-body. Contrariwise, in locusts bred at room temperature the fat-body becomes compact and sponge-like, with an interlacing of the tracheal capillaries. In the cells of the fat-body there is a very little liquid fat and the granules are present but are very small (Pl. xviii, fig. 3).

Towards the end of the life of the immature imagines accumulations of urates can be seen in various parts of the body. In the pericardial cells, the fat-body, and particularly in the Malpighian tubes and the intestine, there are the sparkling red granules of the urates. The excrement of the insects loses its normal appearance, becoming liquid and full of red granules. The accumulation of the urates cannot be the cause of the retardation in the development of the genital products of the locusts in this experiment, because the urates are accumulated only towards the end of their life. The retardation in the development of these locusts has an analogy with the diapause of certain Lepidoptera, which remain immature in the imaginal stage during some months, and are reactivated after a hibernation period.

To complete the analogy with Lepidoptera it is necessary to find in the locusts symbiotic micro-organisms analogous to the yeast-like bodies in the fat-cells of the Lepidoptera. Similar micro-organisms have been described in the ACRIDIDAE. Thus *Coccobacillus acridiorum*, d'Hérelle, supposed to be a pathogenic parasite in locusts (1911), has now been proved by Mereshkovsky¹² to be a normal symbiont, always present in their blood in varying quantities.

In the blood of grasshoppers of the genera *Caloptenus* and *Stenobothrus* Hollande & Moreau⁶ have described small yeast-like organisms 4–6 μ in length and 1–1.4 μ wide, which multiply by budding and represent the vegetative stage of the development cycle of the fungus *Isaria stenobothri*.

As in the case of *Coccobacillus acridiorum*, d'Hérelle, the large accumulation in the blood of *Stenobothrus* of these micro-organisms provokes septicaemia and results in the death of the grasshoppers. In my experiments I was also able to observe in the blood of nymphs of locusts the increase of the coccobacilli during the periods before the moults, when the quantity of blood increases markedly. Probably the periods of moulting are critical for the nymphs, which at these times succumb very easily to the bacterial disease (septicaemia). One of my experiments gives a proof of this (17.iv.1925). In this experiment some nymphs of locusts were transferred

before the final moult from the cage with a temperature of 28°C., where they had been bred, to a cage with a temperature of 20°C. and humidity near to saturation. After three days they became ill, becoming sluggish and dark in colour, and ceased to feed. The quantity of their blood was much increased, and the blood grew muddy. Afterwards the insects began to die, and after death the bodies became hardened. The examination of the blood of these in the bacteriological laboratory of the State Institute of Experimental Agronomy in Leningrad disclosed the presence of *Coccobacillus acridiorum*, d'Hérèlle. After five days (22.iv.1925) the temperature in the cage was raised to 28°C. and the humidity lowered to 50 per cent. Most of the nymphs died before 27.iv., but some recovered after the rising of temperature, began to feed and moulted to the imaginal stage.

The results of this experiment confirmed the opinion of Mereshkovsky, that *Coccobacillus acridiorum* is a normal symbiont in the blood of locusts, but at the same time they showed that this symbiont can become a dangerous parasite under unfavourable conditions of temperature and humidity.

The works of Paillot⁴, Hollande & Moreau⁶, and White⁵ have shown that various coccobacilli are connected with different insects. It may be said that each species of insect has its own species of *Coccobacillus*. These cocco-bacilli are normal to the insects and perform some useful function for their hosts; for instance, they may help to liquefy the connective tissues in the periods of moulting and to accumulate the urates; but under unfavourable conditions they change their behaviour and become parasites in the body of their hosts.

A similar relation of symbiotic bacilli to the tissues of their hosts has been described concerning *Bacterium radiculicola* in the nodules of the roots of plants of the order Papilionaceae. This species live normally as a symbiont in the nodules, where it accumulates reserve materials for the plant, but, as has been shown by experiments at the Rothamsted Experimental Station (1924), in unfavourable conditions it becomes a parasite and destroys the tissues of its host.

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Internal Organs of *Locusta migratoria*, L., ♂ on
the first day of the imaginal stage x 8

Fig 1 Air sacs Fig 3 Testicle
 2 Fat body 4 Accessory glands

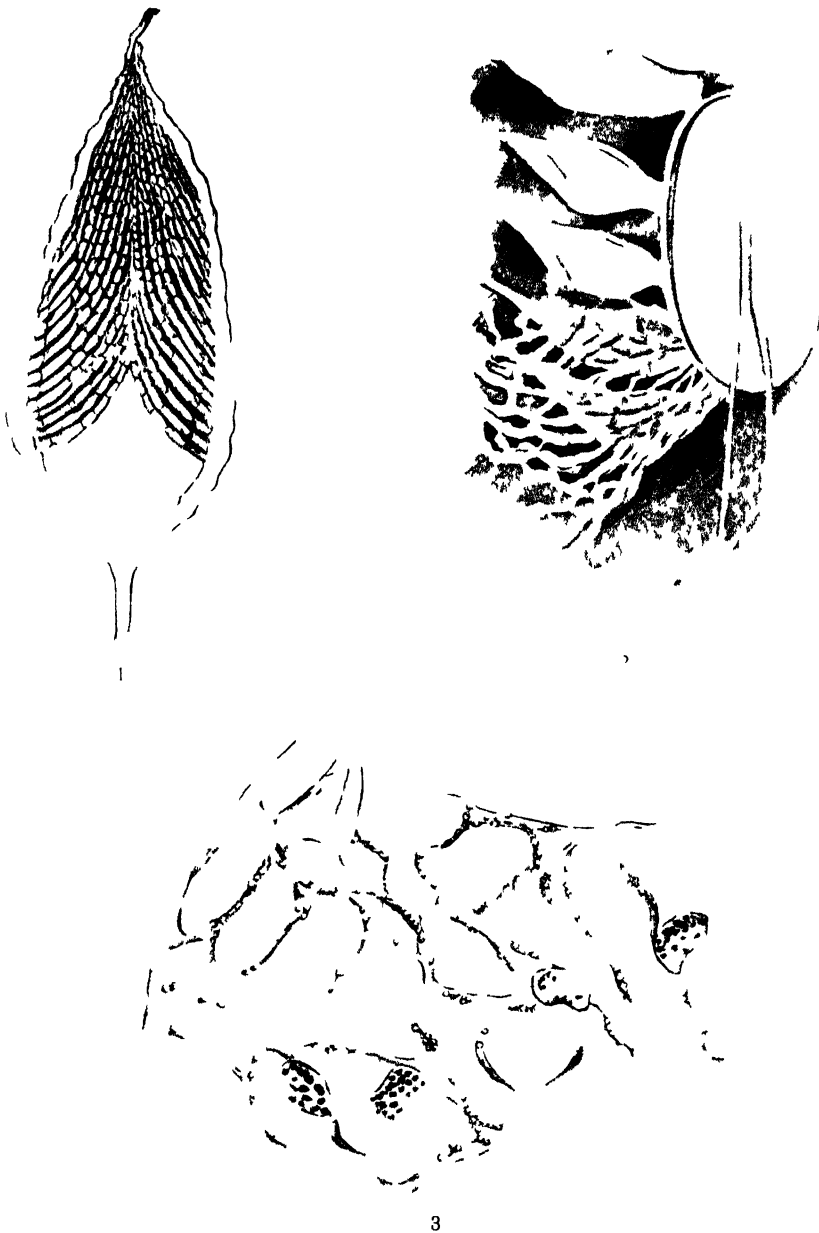
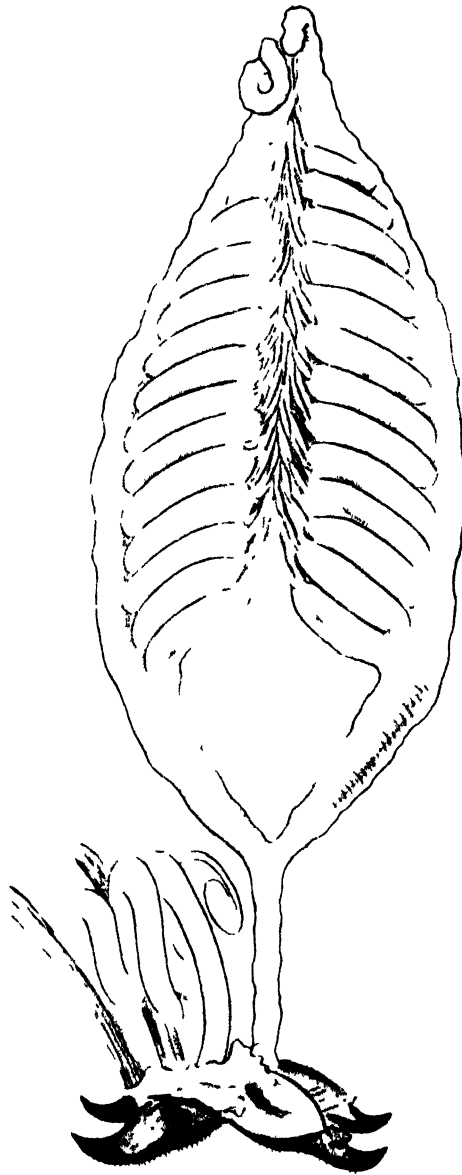


Fig 1 Ovaries of *Locusta migratoria* on the first day of the imaginal stage $\times 10$
 2 Collapsed air sacs of *L. migratoria* $\times 10$
 3 Fat body of imago during diapause Zeiss apochr 2 mm comp. ocul 4



Ovaries of *Locusta migratoria* after migration

NOTES ON THE SWEET POTATO PYRALID MOTH, *MEGASTES GRANDALIS*, GUEN.

By J. W. COWLAND, B.A., Dip. Hort. (Cantab.).

Introduction.

The sweet potato Pyralid moth (*Megastes grandalis*, Guen.) was first described from Brazil by Guenée (Delt. and Pyr., p. 376, 1854). There have been no other records until Urich recorded it as a pest in the Reports of the Department of Agriculture for Trinidad and Tobago for the years 1919 and 1920. It is well distributed throughout the island and during certain seasons is a very serious pest, being undoubtedly responsible for the high price of sweet potatoes in Trinidad, since quantities are imported from the Northern Islands, where the moth so far has not been recorded.

This paper has been prepared in the hope that a description of the early stages of this moth will be useful to enable it to be recognised if it finds entry into other countries.

Nature of Damage.

The damage is done by the larva, which feeds on and tunnels through the portions of the plant underground, only leaving the cortex untouched. The effect on the plant is noticed especially during the dry season in the stunting of its growth, and the shedding of its leaves with consequent lack of tuber production. If tubers are formed, the larva often penetrates down to them through the roots and riddles them with tunnels, in size about equal to its own width. There is no visible sign that the tuber is attacked until it is cut across, when the tunnels can be seen. It is seldom that the skin is broken by the larva inside, although the feeding may be very close to the surface. The burrows are always clean and free from rot, which contrasts with the damage done by weevil larvae. The presence of the larva in the plant can be recognised by the stunting and shedding of the leaves of the plant; by the accumulation of frass on the surface of the ground around the crown; by the splitting of the crown and by the ease with which it can be broken off.

The mortality of cuttings is often due to the presence at the time of planting of larvae which destroy the internal tissue before roots have been developed.

Description of the Egg.

The eggs are oval in outline, flattened, about 1.5 by 1.2 mm. When laid in captivity they are sometimes almost globose. When laid together they overlap one another. They are bright green in colour, later becoming a dull purple colour at the time of hatching, when they are very difficult to see on the plant. They are slightly corrugated with an irregular hexagonal network. They are firmly fixed to the plant so that the empty shells remain in position, and are obvious on account of their translucent white colour.

Description of the Larva.

The larva when full-grown measures 30 mm. long by 4 mm. wide. The head is chestnut brown and the body white, strongly suffused with pink on the dorsal surface. Pinnacula on the body segments brown. The first and second stage larvae do not show the pink colouration of the later instars.

Only primary and subprimary setae are present. Pro-legs five pairs; crochets triordinal in a penellipse broken outwardly; prothoracic shield nearly as broad as segment, divided; a narrow shield on posterior margin of meso- and meta-notum, without setae. Spiracles oval; prothoracic one larger than the others.

Body setae (fig. 1) moderately long, arising from chitinized annular bases. The dorsal shield of the prothorax bears the normal six setae, three behind the anterior, and three near the posterior margin; β seta is situated postero-dorsal of α seta; δ seta between α and γ setae; ρ seta on a level with ϵ seta. On the meso- and meta-notum β group ($\alpha+\beta$) and ρ group ($\gamma+\rho$) on separate pinnacula. On the abdominal segments (1 to 8), α and β setae on separate pinnacula. On the ninth abdominal segment α seta has migrated ventral of β seta and is situated on the same pinnaculum as ρ seta. On the meso- and meta-thorax ϵ and ρ setae associated together. On abdominal segments (1 to 8) ϵ seta is rudimentary, associated with and ventral to ρ seta. On all segments except the ninth and tenth κ group (κ and η) bisetose, on prothorax in front of spiracle, on other segments ventral to spiracle. A pinnaculum on meso- and meta-thorax bears a subprimary seta θ posterior to the spiracle. It is present on abdominal segments (1 to 7) but does not bear a seta. π group unisetose, but bisetose on the prothorax. A pinnaculum is present postero-ventrally to κ group, bearing the subprimary seta μ on the eighth abdominal segment only; σ seta present as usual. T group on prolegs trisetose.

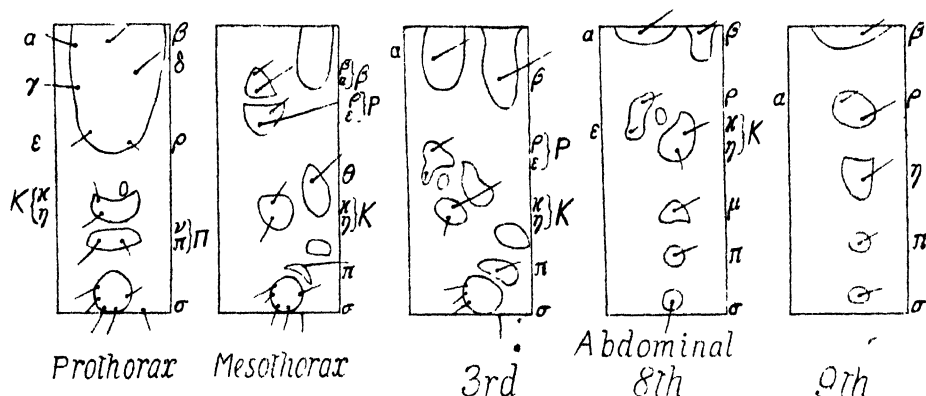


Fig. 1. Diagram showing arrangement of thoracic and abdominal setae in larva of *Megastes grandalis*, Guen.

Head-capsule (fig. 2) spherical, nearly circular in outline viewed from above, a little wider than long; a marked incision on hind margin. Frons (FR) triangular, reaching beyond middle of head; longitudinal suture (LS) shorter than frons. Ocelli six; first four forming a quadrant of a circle; 5 and 6 below; 3 and 4 closer together. Adfrontal sclerites extending as far as the clypeus.

Epicranium with the normal number (13) of primary setae and punctures, and with three minute ultraposterior setae and one puncture. Anterior setae (A_1 , A_2 , A_3) forming an obtuse angle; A_2 equidistant from A_1 and A_3 ; anterior puncture (Aa) posterior to A_2 . Posterior setae (P_1 and P_2) and puncture Pb perpendicular; P_1 just above adfrontal seta (Adf_1); P_2 on a level with the apex of the adfrontal sclerites; Pb approximate to P_2 ; posterior puncture Pa nearer lateral seta (L_1) than any other. Ocellar setae (O_1 , O_2 , O_3) lying behind the ocelli; O_1 approximate to ocelli 2 and 3; O_2 postero-ventral to ocellus 1; O_3 remote from ocellus 6; ocellar puncture (Oa) between O_2 and O_3 setae, approximate and posterior to ocellus 6. Subocellar setae (SO_1 , SO_2 , SO_3) placed in a triangle; SO_3 nearer to SO_2 than is SO_1 ; subocellar puncture below SO_2 equidistant from SO_2 and SO_3 ; genal seta (G_1) and puncture (Ga) present.

Adfrontal setae (Adf_1 , Adf_2) and puncture $Adfa$: Adf_1 at centre of sclerite; Adf_2 above apex of frons; $Adfa$ approximate and below Adf_2 . Frontal setae (F_1) and puncture (Fa) near anterior margin of frons and equidistant from each other.

Clypeus with two normal setae. Labrum with a deep median incision; setae normal, three lateral setae near margin, three median setae placed triangularly; puncture $M\alpha$ between M_1 and M_2 . Mandibles longer than broad with 5 teeth; one long and one short seta on dorsal side just above the condyle.

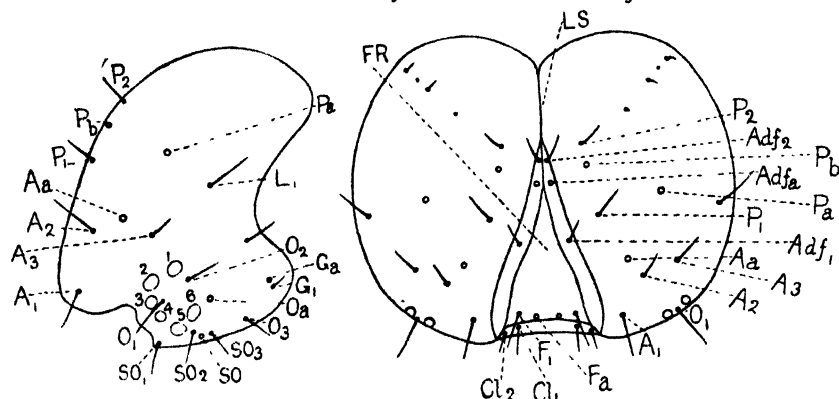


Fig. 2. Diagram showing arrangement of setae and punctures on head of larva of *Megastes grandalis*, Guen. Explanation in text.

Antennae three-jointed, with second one considerably longer than any other; a seta is present at apex of second joint as long as the whole antenna; two papillae also present at apex; third joint surmounted by a small papilla.

Description of the Pupa.

The pupa is 15–18 mm. long, chestnut-brown on dorsal surface, with head somewhat darker; wing-cases and ventral surface yellowish brown. No hooks, setae or tubercles are present; pilifers well developed. Maxillary palpi present; normal sclerites of head present; frontoclypeal suture not apparent; prothoracic and mesothoracic legs not extending forwards between sculptured eyepiece and antennae; wings extending to basal margin of fourth abdominal sternite; metathoracic legs extend to apex of wings; metathoracic legs extending beyond the wings; femora of prothoracic legs clearly indicated; antennae not nearly reaching tips of wings; cremaster absent; spiracles oval and prominently raised; genital opening slit-like in both sexes, and opening large.

Notes on Life-history.

In the field the female selects as concealed a spot as possible for her eggs. They are firmly fixed in the axils of the leaf-petioles or on either side of the basal veins on the underside of the leaf. They may be laid singly, two or three together, or as many as five in a row. They are never laid in a cluster; when several are together one overlaps another in a neat row.

In captivity the number of eggs laid by single females varied from 130–180 deposited over a period of two or three days. Only fertilised eggs will hatch. They take a week to hatch in March and April. In the field only a few eggs can be found on any one plant.

As soon as the larva hatches, it begins to feed near the spot where the egg was laid. Sometimes it only gnaws the surface, but at times bores a short tunnel into the stem. In the field a larva soon leaves and travels on the outside to a position just above the surface of the ground, where it finally enters the stem and bores down the root. It is through this hole or where the stem is split that frass is ejected, so that the tunnels are not fouled.

The length of the larval stage is about 5-7 weeks. When full-grown the larva spins a long silken cocoon from the opening above ground through which the moth will emerge. The exit hole is blocked by silk and frass or by a thin section of rind, which remains lightly attached at the edges. The pupa at the lower end is further protected from the entrance of other insects by a silken funnel around the head end which would not hinder the exit of the moth. Four or five days are spent in the white rather dense silken cocoon before pupation. The pupal period lasts 13-16 days. The empty case remains within the cocoon when the moth issues forth.

The imago hides during the day amongst the leaves. Copulation in captivity took place during the early morning soon after emergence and lasted several hours. Most of the eggs are laid the night following emergence; oviposition may continue for a few days before the female dies.

At present only the sweet potato, *Ipomoea batatas*, is known as a food-plant of the larva.

Parasites.

An egg parasite and larval parasites have been bred from collected material. Eggs which had turned black were found on the muslin of a breeding cage on the 9th March. These were placed in an egg box and on 14th March several parasites emerged, being apparently *Trichogramma minutum*, Riley. The adults were caged with some 4-day-old eggs of the Pyralid, and a second generation of parasites emerged on the 25th March.

Sarcophagid flies (*Sarcophaga sternodonta*, Towns.) were obtained from full-grown larvae. The host develops normally until after it has spun its cocoon, when the parasitic emerge from the host caterpillar and pupate inside the silken cocoon, from which the adult flies appear after 10 to 12 days. Generally two Sarcophagid larvae are able to develop within the body of one caterpillar. A specimen of a Tachinid (*Masicera? abdominalis*, Wulp.) was also obtained.

Mr. Urich tells me that he has seen an Ichneumonid parasite (*Xiphosoma azteca*, Cress.) piercing the eggs of *Megastes grandalis*; later he bred out the parasite from the full-grown larvae that developed from these eggs. The writer has not been able to obtain any specimens of this Ichneumonid from his material.

Summary.

Megastes grandalis was first reported from Brazil; there have been no other records until 1919, when it was reported from Trinidad as a serious pest during certain seasons of the year to the roots and tubers of the sweet potato. At present this is the only known food-plant.

The eggs are laid two or three together in the axils of the leaf-petioles or on the underside of the leaf. The larva at first feeds near the place where it hatches, then travels to the base of the stem and bores its way in, eating out tunnels through the roots and tubers, leaving the cortex untouched. It pupates in a silken cocoon near the surface. The moths live only a few days during which oviposition takes place. Descriptions of the immature stages are given. The writer obtained a *Trichogramma* egg parasite and Tachinid larval parasites.

This work was undertaken at the Imperial College of Tropical Agriculture, Trinidad, West Indies.

The Imperial Bureau of Entomology kindly identified the parasites.

NOTES ON ENCYRTIDAE (HYM.-CHALCIDOIDEA) BRED FROM
PSYLLIDS, WITH DESCRIPTION OF A NEW SPECIES.

By A. B. GAHAN, *Bureau of Entomology, United States Dept. of Agriculture,*
and

J. WATERSTON, *British Museum (Nat. Hist.), London.*

Specimens of the interesting new species described herewith came into the hands of both authors of this paper at about the same time from the same source, and were determined by each as new to science. Each being in ignorance of the fact that the other had received specimens, both proceeded to describe it. Before either description was published, however, the duplication was discovered through correspondence, and the description has been made the subject of this joint paper. The type and allotype specimens are in the United States National Museum, but paratypes are in the British Museum as stated below.

Family ENCYRTIDAE.

Tribe MIRINI.

***Psyllaephagus arbuticola*, sp. n.**

This species is not a typical *Psyllaephagus*, since it differs from the type species, *P. pachyphyllae* (Howard), in the following particulars: The antennae of the female are more elongate and more slender, with the funicle joints all two or more times as long as thick, the first funicle about one-fourth less than the pedicel, the club less than half as long as the funicle and only slightly thicker than the funicle; marginal vein fully twice as long as broad, post-marginal very short, stigmal approximately equal to marginal; ovipositor distinctly exerted. Male antennae (fig. 1, *a*) long; pedicel small, subglobose; funicle joints thick, cylindrical, subequal, three or more times as long as thick, except the last two joints which are somewhat shorter. These characters are all purely relative ones. In view of the agreement otherwise with *Psyllaephagus* it is the opinion of the writers that it will be better to place the species in that genus tentatively than to erect a new genus for its reception.

Female.—Length, 1.5 mm. Head finely reticulate-punctate; fronto-vertex distinctly broader than long, with a few rather obscure round punctures; scrobes subtriangular, rounded above, and moderately deep; malar space subequal to half the eye-height; mandible (fig. 1, *b*) tridentate, the teeth subequal in length, the inner tooth acute, the two outer ones blunt and rounded at apex. Antennae (fig. 1, *c*) slender, the scape slender and as long as the first four funicle joints combined; pedicel a little more than twice as long as thick at apex, somewhat thicker and very slightly longer than the first funicle joint, which is three times as long as thick; following funicle joints subequal to the first in length, but very slightly increasing in thickness so that the sixth is about twice as long as thick; club 3-jointed, sub-cylindrical, rounded at apex, very slightly thicker than the last funicle joint and somewhat longer than the two preceding funicle joints combined. Mesoscutum sculptured like the vertex; scutellum more finely and deeply sculptured, with the punctures or interspaces elongate and narrow. Forewings (9:4) (fig. 1, *d*) as long as the whole body, with a narrow triangular area which is broadest at the posterior margin of wing and extends obliquely forward and distad nearly to the stigmal vein, destitute of cilia; basad of the non-ciliated area the wing is coarsely and rather sparsely ciliated, while distad of it the ciliation is fine and dense; submarginal: marginal and postmarginal, 11:13; marginal, stigmal and postmarginal in ratio 7:6:3. Propodeon smooth and short; abdomen as long as the thorax, ovate, practically without sculpture, except on the underlying half, the second tergite where there is a complete transverse band of hexagonal cells 4-6 deep. In *P.*

pachypsyllae (How.) (fig. *e, f, g*) this band is absent, but at the sides of tergites 2-5 is a patch of bullet-shaped cells, 5-9 in number, similar to those on tergite 2 of *P. cellulatus*, Waterst. (1922); ovipositor exerted a little over one-fourth the length of abdomen. Mid tibia with 6 heavy apical spines, and the following on the plantar aspect of the tarsal joints: 11, 10, 7, 5. In the male these spines are less numerous, about 7 on the first mid tarsal joint and 4-5 on the second to the fourth.

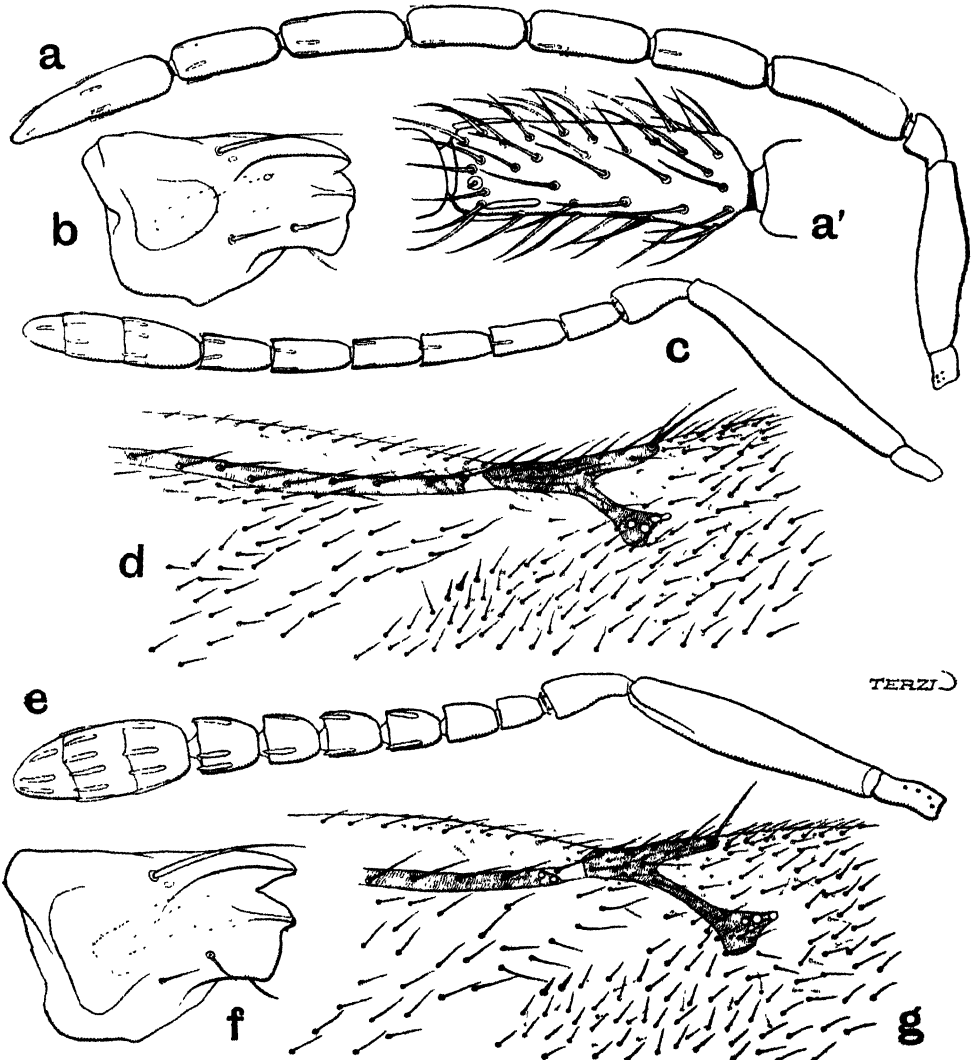


Fig. 1. *Psyllaephagus arbuticola*, Gah. & Waterst.: *a*, antenna of ♂; *a'*, third funicular joint; *b*, mandible of ♀; *c*, antenna of ♀; *d*, neuration of fore wing, ♀. *Psyllaephagus pachypsyllae*, Howard, ♀: *e*, antenna; *f*, mandible; *g*, neuration of fore wing.

Fronto-vertex, mesoscutum, and scutellum dull metallic green, the mesoscutum along the posterior border and the axillae more or less dull purplish black, the scutellum blackish at base; head, except fronto-vertex, black with a faint bronzy lustre in some lights, the ridge between antennae more or less strongly metallic;

metanotum, propodeon and underside of thorax black; abdomen black except at base above, which is bright metallic green; antennal scape black, with the extreme apex brownish yellow; pedicel dark brown, with the apex yellowish; flagellum dark brown; legs black, with all trochanters, apices of all femora, fore and median tibiae entirely and all tarsi pale yellowish; hind tibiae pale yellowish with a broad fuscous or blackish band near base; wings hyaline, venation brownish.

Male.—Length, 1.2 mm. Antennae (fig. 1, *a, a'*) as long as the body; scape flattened and slightly expanded beneath; pedicel barely longer than broad at apex; first funicle joint fully three times as long as thick, following joints successively very slightly shorter, the sixth about two and a half times as long as broad; club solid, subcylindrical, rounded at apex, not broader than the funicle and not quite as long as the last two funicle joints combined. Fronto-vertex shorter and more strongly sculptured than in the female, about twice as broad as long. Abdomen ovate, about two-thirds as long as the thorax. Other characters as in the female.

Type-locality.—San Mateo County, California.

Type.—Cat. No. 26076 U.S.N.M.

Described from the following specimens: Six females and three males in the U.S. National Museum and one female in the British Museum, taken in July by Albert Koebele in San Mateo and Alameda counties, California, and said to have been reared from a Psyllid on *Arbutus*; also two males and one female in the U.S. National Museum and three males and two females in the British Museum, said to have been reared 2nd May 1922, at Stanford University, California, from *Euphyllura arbuti* by P. Hyatt, and sent to the respective Museums for determination by G. F. Ferris.

***Psyllaephagus solus*, Howard.**

Encyrtus solus, Howard, U.S. Dept. Agric., Div. Ent., Bull. 5, 1885, p. 15.

Scaptophorus solus, Ashmead, Proc. U.S. Nat. Mus., xxii, 1900, p. 381.

The types of this species are congeneric with the new species, *arbuticola*, described herewith. The two species are easily separated by the fact that in *solus* the legs, with the exception of the middle and hind coxae, are entirely pale yellowish; the forewings are distinctly dusky beyond the apex of venation, the infuscation being heaviest along the anterior and apical margins; the fronto-vertex, in addition to being finely reticulate-punctate, is sparsely set with a number of distinct round punctures and is distinctly longer than broad, the scrobes being considerably shorter than in *arbuticola*; the first funicle joint is slightly longer than the pedicel, and the stigmal vein is not as long as marginal and postmarginal combined, but subequal in length to the marginal.

The U.S. National Museum collection contains six female specimens from Jacksonville, Florida, all apparently reared at the same time and from the same material as the type.

***Psyllaephagus euphyllurae*, Silv.**

Encyrtus euphyllurae, Silvestri, Boll. Lab. Zool. Gen. Agr. Portici, v, 1911, p. 169.

Psyllaephagus euphyllurae, Mercet, Fauna Iberica, Himenopteros, Fam. Encirtidos, Madrid, 1921, pp. 351, 699–700, fig. 290.

This species, unfortunately omitted in the list of Chalcid parasites of Psyllids given by one of us in this Bulletin (xiii, May 1922, pp. 41–58) parasitises *Euphyllura olivina*, Costa, attacking the olive (*Olea europea*, L.). It has been reported, up to the present, from Italy, Sicily and Portugal.

A NEW GEOMETRID MOTH ATTACKING DEODARS IN INDIA.

By LOUIS B. PROUT.

***Ectropis deodarae*, sp. n.**

♂, 38–40 mm. Face rough-scaled. Palpus rather short, rough-scaled beneath. Tongue rather short and slender. Antenna with ciliation about 1, not or scarcely fasciculate. Thorax apparently not crested. Pectus densely hairy. Femora moderately hairy. Hind tibiae not dilated. Abdomen slender, not long. Head and body brown-grey, slightly paler beneath than above; fore leg banded.

Wings rather delicate and smoothly scaled. *Forewing* with costa long; apex rounded, termen smooth, long, very oblique; no fovea; cell half or just over, DC straightish; SC¹⁻² short-stalked; grey, more or less tinged with brown and irrorated with black, some black dashes on the veins, especially just beyond the postmedian line, where those on R³ and M¹ are strong; lines black; antemedian fine, excurved anteriorly, then oblique inward, accentuated at the veins and at hindmargin; median weak except at costa, rather diffuse in cell, thinner posteriorly, twice as near antemedian at hindmargin as at costa; postmedian firmer, arising from a small costal spot about 7 mm. from apex, slightly incurved between SC⁵ and R¹, direct to hind angle of cell, gently incurved between this and SM², slightly thickened at hindmargin, which it reaches about the middle; slight dark shades on reverse sides of ante- and postmedian; subterminal somewhat sinuous, accompanied proximally by slightly interrupted blackish shading; termen with strong black interneural dots; fringe with a very fine pale line at base and a weak dark-grey dividing line. *Hindwing* with termen waved; slightly paler; median line faint, visible only in posterior part; postmedian irregularly sinuous, approximately analogous to that of forewing, but rather less strong and slightly dentate outward on the veins; subterminal and its shade weaker than on forewing, evanescent costally.

Underside rather paler, almost uniform; faint traces of the markings of upperside.

♀. Semiapterous. Abdomen moderately robust. Ovipositor long. Fore leg banded, much as in the ♂. *Forewing* about 4 mm. in length, triangular, termen not oblique; colour as in ♂; postmedian just beyond middle black, slightly sinuous, sometimes thickened, band-like; antemedian generally rather weaker. *Hindwing* rounded apically, produced tornally, somewhat as in *Erannis marginaria*, Fabr., though less extreme; postmedian line strong.

UNITED PROVINCES: Kathian, Chakrata, 2.ii.1924, 5 ♂♂, 2–5.ii, several ♀♀.

Type in coll. Brit. Mus., received from Dr. C. F. C. Beeson through the Imperial Bureau of Entomology.

I have a ♀ from Kasauli, 2.iv.1921, which was kindly given me by Capt. P. J. Barraud and has long awaited description. Dr. Beeson adds that he has records also from Tehri Garhwal State, several of the Simla Hill States, the Simla Government Forests and Chamba State. "It appears to be confined to the deodar forests of the outer Himalayas. The moths were obtained by rearing from the hibernated stages in the insectary, Dehra Dun."

Some irregularities in structure and especially the very interesting discovery of the *Erannis*-like ♀ led me to question my generic placing, and I submitted the genitalia to my valued friend and counsellor the Rev. C. R. N. Burrows, who writes: "Its nearest relation in the English fauna would appear to be *Ectropis*. Valves long, narrow; costa thickened. Uncus strong, tapered, ? without pads. Gnathos incomplete, partly fused. Aedoeagus long, cylindrical, thumbled at the orifice.

Vesica scobinate. Cristae long, each terminating in a *point*." ♀ signum, however, not of the typical, stellate *Ectropis* type, but apparently more like that of *Erannis marginaria*.

Dr. Beeson has recently published (Indian Forester, li, no. 11, Nov. 1925, pp. 565-572, 1 pl.) a full account of the life-history and habits of this insect, of which he has given figures. During the past five years the deodar forests on the outer ranges of the Western Himalayas have suffered severely from the attacks of the larvae. The outbreaks have been sporadic, lasting generally for two years and then suddenly dying out. Large areas of pure deodar forests have been completely defoliated in the spring, and in the following year up to 30 per cent. of the trees have died. After defoliation in two consecutive years still more serious mortality of the trees may occur.

SOME TERMITES FROM CEYLON.

By N. A. KEMNER, D.Sc.

Stockholm, Sweden.

Some months ago I received from Dr. Guy A. K. Marshall, Director of the Imperial Bureau of Entomology, London, a collection of termites from Ceylon which he kindly entrusted to me for the purpose of identification. The termites were collected by the Government Entomologist of Ceylon, Mr. T. C. Hutson, in different parts of the island, in tea plantations. If this is the case, the termites were presumably not collected on the plains but at some height above the sea-level, where tea preferably is cultivated. There are, however, no detailed records of the height of the localities.

The collection, comprising 41 tubes containing workers and soldiers, the castes which it is easiest to find in the nests, is of interest because it adds considerably to our knowledge of the termite fauna of Ceylon, partly by increasing the number of species known from the island, partly by widening our knowledge of the variation to which these insects are subject.

As a whole the termites of Ceylon are amongst the best known from a biological as well as from a systematic point of view. Already early collectors have worked there, amongst others, Nietner, who sent both termites and other insects to Europe to get them described, and made important notes on their biology, thus laying the foundation of our knowledge of Ceylon termites. The famous Hagen made use of Nietner's notes and collections, and his excellent monograph of the termites of the world (1855-1860) contains much information about the termites of the island. Other entomologists followed in his steps. Wasmann and Desneux have written important papers on the Ceylon termites, several of the characteristic species having been named by them. The most important contributions have, however, been made during recent times by entomologists such as Guignon, Petch, Escherich, Holmgren and others.

In spite of this there are many gaps in our knowledge of these insects, which is explained by the special difficulties inherent in their study. Their classification and their biology have been comparatively little studied, and many opinions that have not sufficient foundation will undoubtedly in future have to be altered.

The general features of the classification are certainly comparatively well known, but our knowledge of the different species is far less sure. Some species cannot be clearly defined from others, there being series of apparently intermediate forms between them, with the result that nobody knows where to draw the line. Measurements have always, and especially in later investigations, been largely used in distinguishing species, but Fuller, as a result of his important researches on South African termites, has shown that these must be used with great discrimination, because the age of the nest plays a more important part as regards the size of the individual than the age of the individuals themselves. The same author has also proved that the length of the basal joints of the antenna, which has hitherto been considered a very important character, is very variable, the result being that any measurements must be taken from a long series of individuals. Furthermore, the nomenclature is in a rather unsettled state, many of the older diagnoses being founded on material that on closer examination has proved to consist of castes belonging to different species and genera, which adds to the confusion, because it is impossible to tell which names are valid. As an instance of this confusion it may be mentioned that, as late as 1893, Wasmann described a species, *Odontotermes redemanni*, from material which very likely contained two species of *Odontotermes* soldiers besides the soldier of a species of *Eutermes*, which he, remarkably enough, considers to be the worker of the *Odontotermes*.

An examination of the older types has also revealed the fact that some of the most common specific and generic names must be altered, if the rules of priority be strictly adopted. For my own part, adhering to the view that older names should not be altered unless the change serves some useful purpose, I have in this paper used the common names. There is the more reason for this view, as the most comprehensive work on the termites of Ceylon, Escherich's "Termitenleben auf Ceylon," employs the same names.

A list of the species found in the collection is given below. The new forms are marked with a *.

Family PROTERMITIDAE, Holmgren.

Calotermes militaris, Desn.

**Calotermes militaris* ab. *unidentatus*, n.

Calotermes greeni, Desn.

Calotermes dilatatus, Bugn. & Popoff.

Family MESOTERMITIDAE, Holmgren.

Coptotermes ceylonicus, Holmgr.

Family METATERMITIDAE, Holmgren.

**Odontotermes horni*, Wasm., var. *hutchinsoni*, n.

**Odontotermes horni*, Wasm., var. *minor*, n.

Odontotermes ceylonicus, Wasm.

Odontotermes redemanni, Wasm.

Odontotermes escherichi, Holmgr.

**Odontotermes marshalli*, sp. n.

Eutermes ceylonicus, Holmgr.

**Eutermes ceyloniellus*, sp. n.

Eutermes rubidus, Hag.

Microcerotermes bugnioni, Holmgr.

Microcerotermes greeni, Holmgr.

**Capritermes hutsoni*, sp. n.

Family PROTERMITIDAE.

1. *Calotermes militaris*, Desneux (1904).

This large species was described by Desneux, but the detailed diagnosis was given by Holmgren's measurements in his monograph. A closer examination of the present material shows, however, that the size is subject to great variations, which must be taken into account when characterizing the species.

Imago.—In one tube (No. 4369) there is one imago, which in one respect seems to differ from the description given by Holmgren. The pronotum is only 2.15 mm. wide, while Holmgren gives 3.08. This is, however, probably a lapsus calami of Holmgren's, as the width of the head is only ca. 2 mm. and the species of *Calotermes*, as a rule, have the pronotum and head of the same width. Other measurements differ also slightly in the following way:—

	(Acc. to Holmgren.)	(No. 4369.)
	mm.	mm.
Length with wings	17.00	19.00
Length without wings	10.00–12.00	9.50
Length of anterior wings	—	16.58
Width of head	2.05	1.91
Width of pronotum	3.08 (2.08?)	2.15
Length of pronotum	1.29	1.27

The present specimens seem to be distinctly longer than Holmgren's measurements, especially those with wings. The variation is probably quite fortuitous and does not constitute a specific character. The antennae, when 18-jointed, sometimes have the 3rd joint distinctly longer than the 2nd and 4th, not, as Holmgren describes, the three joints of equal length.

Soldier.—The measurements and the antennae differ slightly from Holmgren's description :—

	(No. 5995.)	(No. 6321.)
	mm.	mm.
Length of body	8.17	11.00
Length of head with mandibles	4.90	5.00
Length of head without mandibles	3.00	3.00
Width of head	1.98	2.05
Width of pronotum	1.98	2.30
Length of pronotum	0.95	1.06

The great variation in the width of the pronotum is very remarkable, but Holmgren states (*Termiten Studien*, iv, p. 42) that this species is rather variable.

As already pointed out by Green and others, this species seems to live in tea bushes; the following data are given on the labels:—

CEYLON: Talawakelle, 9.viii.1923, "living tea bush"; 21.xi.1918, "branches of tea"; Maskeliya, 22.ix.1921, "stem and roots of tea"

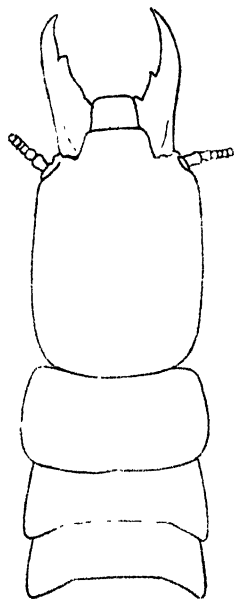


Fig. 1. *Calotermes militaris*, Desn., ab. *unidentatus*, Kernn., nov.

2. *Calotermes militaris* ab. *unidentatus*, n.

One of the tubes contained a soldier, two neotenicis and some nymphs, of which the soldier especially differs from the typical form. If there had been more material I should not have hesitated in describing it as a new species. As there is only one soldier, although in good condition, I prefer provisionally to describe it as an ab. of *militaris*, to which species it is undoubtedly most closely related. The obvious differences from the normal *militaris* can possibly be explained as due to an influence in a neotenic direction, evident by the shape of the sides of the meso- and metanotum.

Soldier.—In all essentials resembling the soldier of *C. militaris*, but larger. The left mandible is of different shape, having in the distal part only one larger tooth in the same place where the anterior tooth of *militaris* is inserted; behind this there is no second tooth, the edge being even to the small incisions behind which the great basal tooth is to be found; the right mandible is of the same shape as in *militaris*. The antennae are 18-jointed, the 2nd, 3rd and 4th joints being successively slightly shorter, and the 5th equal to the 3rd. Pronotum of the same shape as in *militaris*, but somewhat broader. Meso- and metanotum differing by the narrow, backwardly produced posterior angles and the deeply excavated posterior margin. As in the normal soldier of *militaris*, there is close behind the antenna an eye-spot with some facets, which is however slightly larger and with more facets than in *militaris*.

Length of body	...	...	...	...	11.00 mm.
Length of head with mandible	...	...	...	...	5.09
Length of head without mandible	...	...	...	...	3.18
Width of head	...	...	...	...	2.40
Width of pronotum	...	...	...	...	2.44
Length of pronotum	...	...	...	...	1.16

Neoteinics.—Two specimens of normal shape are present in the collection, both without specially protruding posterior angles on the meso- and metathorax. They are comparatively strongly chitinized and of a yellowish-brown colour. The antennae are 17- or 18-jointed, with joints 3 and 4 small, together equal to 2.

Length of body	...	...	...	...	7.00-8.50 mm.
Width of head	...	...	...	...	1.55-1.62
Width of pronotum	...	...	...	...	1.91-1.94
Width of mesonotum	...	...	...	...	2.01-2.05
Width of metanotum	...	...	...	...	1.87-1.98

Nymphs of different sizes occur, some of which have rather long wing-cases.

CEYLON: Bogawantalawa, 26.ii.1921, "branches, stems and roots of tea."

This species is remarkable for the produced posterior angles of the meso- and metanotum of the soldier. This feature is possibly due to the fact that the soldier has been influenced in a neoteinic direction. The shape of the abdominal segments and those parts of the anatomy which can be discerned through the rather hyaline cuticle do not, however, indicate sexual maturity.

3. *Calotermes greeni*, Desneux (1904).

Imago.—The imago seems to have a much darker, nearly black head when old, the heads of the younger specimens having a lighter colour, as described by Desneux. The measurements show variation:—

	(No. 5996.)	(No. 6106.)
	mm.	mm.
Length with wings	14.00	—
Length without wings	8.00	9.00
Length of anterior wings	11.00	—
Width of head	1.52	1.52
Width of pronotum	1.55	1.45
Length of pronotum	0.85	0.85

Pronotum longer than in the typical specimens. The length of the 2nd joint of the antenna variable.

Soldier.—The measurements show considerable variation :—

	(6238.)	(6106.)	(6294.)	(5996.) deformed	(5996.) normal
	mm.	mm.	mm.	mm.	mm.
Length of body	9.33	9.13	9.70	7.69	11.00
Length of head with mandibles ...	5.09	4.61	5.29	4.23	4.71
Length of head without mandibles ...	3.18	2.79	3.46	2.54	3.00
Width of head	2.19	1.98	2.12	1.87	2.05
Width of pronotum	2.12	1.91	2.23	1.55	2.01

Neoteinic.—One specimen in tube no. 6180. The measurements are as follows :—

Length of body	8.57 mm.
Length of head with mandibles ...	2.08
Length of head without mandibles ...	1.66
Width of head	1.62
Width of pronotum	2.08
Width of mesonotum	2.05
Width of metanotum	1.80

The antennae are broken ; 3rd joint a little shorter than 2nd and 4th.

This well-known termite occurs in five localities. It seems to dwell both in living and dead trunks and roots of tea, and *Grevillea*. A comparatively newly hatched imago was collected in October (5996), and neoteinic individuals occur (6180).

CEYLON: Balangoda, 28.viii.1923, "dead stem of *Grevillea*"; Maskeliya, 21.iii.1923, "stem and roots of tea"; Raltota, 12.1.1924, "dead stem of *Grevillea*"; Elpitiya, Ambalangoda, 18.x.1923, "living tea bush"; Avisavella 3.viii.1922, "living tea bush."

4. *Calotermes dilatatus*, Bugn. & Popoff (1910).

Imago.—This caste was described by Holmgren (Termiten Studien, 4, p. 56), who had only wingless specimens at his disposal. The present material contains winged forms, which enable us to give a fuller description. Antenna with 14 joints, which increase successively in length towards the penultimate joint ; the length of the basal joint varies a little as usual ; generally, joints 2, 3 and 4 are of equal length, but sometimes the 3rd is slightly longer. The wings are light yellowish-brown, except the anterior nerves which are darker ; radius of the anterior wings short, extending only to the basal third of the wing ; cubitus poorly developed, running in the posterior half of the wing, with numerous but rather vague branches.

Length with wings	10.00-10.50 mm.
Length without wings	6.25-7.50
Length of the anterior wings	7.50-7.88
Width of head	1.20-1.30
Width of pronotum	1.20-1.30
Length of pronotum	0.63

Soldier.—The measurements show variation, the width of the pronotum especially being somewhat greater than in Holmgren's specimens :—

Length of body	5.86-8.00 mm.
Length of head with mandibles ...	3.08-3.27
Length of head without mandibles ...	2.05-2.08
Width of head	1.27-1.34
Width of pronotum	1.16-1.41

CEYLON: Ingiriya, 27.vii.1922, "living tea bush"; Ambalangoda, 18.x.1923, "living tea bush"; Ratnapura, 24.vii.1914, "stem of tea"; Elpitiya, 10.iii.1923, "stem and roots of tea"; Elpitiya, Ambalangoda, 21.iii.1923; "stem of tea."

The sample containing newly hatched imagines (6183) was collected in March.

Family MESOTERMITIDAE.

5. *Ooptotermes ceylonicus*, Holmgr.

This is the only species of this genus present in the collection. A comparison with Holmgren's type specimens of *C. ceylonicus* shows that it is most closely related to that species. In order to be quite sure one ought to have the imagines also. The measurements vary a little,* but only within the normal limits of these insects.

Soldier.—

Length of body	...	...	...	...	4.71 mm.
Length of head with mandibles	...	...	...	...	1.99-2.15
Length of head without mandibles	...	...	...	...	1.34-1.41
Width of head	...	...	...	...	1.10-1.23
Width of pronotum	...	...	...	...	0.77-0.81

Antenna 14-jointed; 3rd joint usually small, but sometimes longer with indications of a partition in two.

Worker.—Somewhat smaller than those previously described:—

Length of body	...	...	...	...	3.94-4.80 mm.
Width of head	...	...	...	...	1.13-1.20
Width of pronotum	...	...	...	...	0.67-0.70

CEYLON: Pelmadulla, 13.ix.1922, "dead tea wood"; Avisavella, 2.viii.1922, "rafters of bungalow"; Elpitiya, 10.iii.1923, "dead tea wood"; Avisavella, 2.viii.1922, "dead bark of *Hevea*."

Family METATERMITIDAE.

Odontotermes horni, Wasm. (1902).

This, the largest *Odontotermes* from Ceylon, was found in six different localities, as a rule with soldiers and workers. A closer examination reveals the fact that the variation in size is so considerable, in both soldiers and workers, that it seems desirable to distinguish the different varieties. Very likely these differences are due to the different ages of the nests from which the samples were collected, the larger specimens occurring in the older nests, as suggested by Fuller. Four of the samples I have referred to a variety which is larger than the form described by Holmgren.

6. *Odontotermes horni* var. *huttoni*, n.

Soldier.—

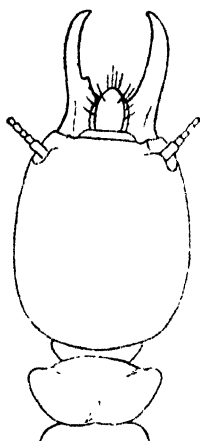
Length of body	...	...	...	...	8.50-10.00 mm.
Length of head with mandibles	...	...	...	...	4.23-4.52
Length of head without mandibles	...	...	...	...	2.62-2.83
Width of head	...	...	...	...	2.12-2.30
Width of pronotum	...	...	...	...	1.66-1.73

Antenna 17-jointed, with long 4th joint, sometimes with indications of segmentation into two.

* In the original description (*Termitenleben auf Ceylon*, 1911, p. 192) the measurements of a soldier, through a printer's error, are quite wrong; this has been corrected in a later paper (*Termitenstudien*, iv, 1913, p. 76).

Larger Worker.—

Length of body	...	...	...	...	6.50-7.50 mm.
Width of head	...	...	...	...	1.87-2.12
Width of pronotum	...	...	...	...	1.09-1.29

Fig. 2. *Odontotermes horni*, Wasm.,
var. *hutsoni*, Kemn., nov.Fig. 3. *Odontotermes horni*, Wasm.,
var. *minor*, Kemn., nov.

Antenna 19-jointed; joints 2, 3 and 4 of about equal length. The anterior margin of the pronotum with distinct median incision concave.

The considerably broader head of the soldier, as well as the greater size and the shape of the pronotum of the worker, distinguish this form clearly from the typical form described by Holmgren.

CEYLON: Peradeniya, 10.v.1922, "in dead coconut log"; Avisavella, 20.v.1922, "dead wood of living tea"; Avisavella, 20.v.1922, "living tea bush"; Deniyaya, 26.x.1921, "roots of cacao."

7. *Odontotermes horni* var. *minor*, n.

The collection contains also some specimens which in their smaller size differ from both the typical form and the new var. *hutsoni*.

Soldier.—

Length of body	...	...	...	...	7.69-8.80 mm.
Length of head with mandibles	...	...	...	...	3.84-4.04
Length of head without mandibles	...	...	...	...	2.47-2.65
Width of head	...	...	...	...	1.84-1.98
Width of pronotum	...	...	...	...	1.35-1.52

Antenna 16- to 17-jointed. When 16-jointed the 3rd joint is much longer than the 2nd and shows traces of partition in the middle; in the 17-jointed antenna the 3rd joint is very short.

Worker (probably large worker).—

Length of body	...	...	...	...	4.32-4.61 mm.
Width of head	...	...	...	...	1.59
Width of pronotum	...	...	...	...	0.92

Antenna (17) to 18-jointed; 4th joint, when present, very short. Anterior margin of pronotum slightly concave.

From its smaller size this variety seems to come from a younger nest, where the nourishment is poorer than in the old nests.

CEYLON: Raltota, 28.viii.1921, "on dead wood of living tea"; Avisavella, 2.viii.1922, "dead bark of *Hevea*."

8. *Odontotermes ceylonicus*, Wasm. (1902).

Soldier.—The soldiers of this species present in the collection are usually smaller than those described by Holmgren.

Length of body	...	...	...	...	5.38–6.63 mm.
Length of head with mandibles	...	...	...	...	2.62–2.97
Length of head without mandibles	...	...	...	...	1.55–1.84
Width of head	...	...	...	...	1.20–1.38
Width of pronotum	...	...	...	...	0.88–1.02

Worker.—

Large.			Small.		
Width of head	...	1.45 mm.	Width of head	...	0.99 mm.
Width of pronotum	...	0.81	Width of pronotum	...	0.63

One of the tubes contained eggs, of the usual oval form, measuring 0.77×0.35 to 0.67×0.28 mm.

CEYLON: Elpitiya, Ambalangoda, 28.iv.1924, "from tea bush, riddled by *Calotermes dilatatus*"; Avisavella, 2.viii.1922, "dead bark of *Hevea*" (with one soldier of *Coptotermes ceylonicus*); Ukuwella, 22.ix.1922, "dead tea wood."

9. *Odontotermes redemanni*, Wasm. (1893).

The size of the soldiers and workers agrees closely with the measurements given by Holmgren. The antennae are sometimes 16-jointed, while Holmgren mentions 17 joints, the difference being obviously due to whether the 3rd joint is complete or divided.

CEYLON: Avisavella, 20.v.1922, "living tea bush."

10. *Odontotermes escherichi*, Holmg. (1911).

This, the smallest of the species of *Odontotermes* found in Ceylon, was probably described already in 1893 by Wasmann, who, however, considered it to be a small soldier of *O. redemanni*. It was described as a new species by Holmgren on material brought home by Escherich. In 1914, Holmgren supplemented this description by the diagnosis of the imago, which Escherich failed to find.

The present material adds further to our knowledge of the species, as it contains also the small workers, which one would expect to find in this as in all other species of the genus. Eggs are also present.

Soldier.—Measurements sometimes slightly different from those given by Holmgren.

Length of body	...	...	...	...	4.52 mm.
Length of head with mandibles	...	...	...	...	1.73–1.82
Length of head without mandibles	...	...	...	...	1.05–1.09
Width of head	...	...	...	...	0.93–1.02
Width of pronotum	...	...	...	...	0.68–0.74

Large Worker.—

Length of body	...	...	...	...	3.85 mm.
Width of head	...	...	...	...	1.13
Width of pronotum	...	...	...	...	0.68

Small Worker.—Head light yellowish; body white with numerous hairs. Head oval, longer than its width, not as flattened as in the large worker. Clypeo-basal more convex, frons without impression behind the clypeo-basal. Median epicranial suture somewhat depressed. Antenna 16-jointed; 2nd joint as long as $3 < 4$, 4th joint shorter than 3rd, which is of the same length as the 5th. Pronotum of the same shape as in the large worker, with scarcely concave anterior and posterior margin, but with a longitudinal depression.

Length of body	...	...	...	...	2.69–2.88 mm.
Width of head	...	...	...	...	0.74
Width of pronotum	...	...	...	...	0.50–0.51

Egg.—Oval, sometimes with one of the sides concave; $0.63\text{--}0.67 \times 0.35\text{--}0.36$.

CEYLON: Raltota, 29.v.1922, "dead stem of *Grevillea*"; Elpitiya, Ambalangoda, 10.iii.1923, "soil near dead tea bush."

11. *Odontotermes (Hypotermes) marshalli*, sp. n.

Of the subgenus *Hypotermes* hitherto the following species have been described: *obscuriceps*, Wasm., from Ceylon; *xenotermis*, Wasm., from Pegu; and *sumatrensis*, Holmgr., from Sumatra. The subgenus, characterized by the small heads being of equal width throughout and the mandibles having no large teeth, is, however, represented in Ceylon by yet another species, which is of greater size than any of those previously described.

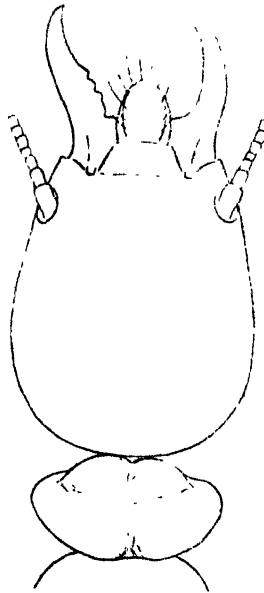


Fig. 4. *Odontotermes (Hypotermes) marshalli*, Kemn., sp. n.

Soldier.—Head brown, anteriorly somewhat lighter, distinctly darker than the yellowish-white body; antennae brown; palpi and labium light brown; mandibles light at the base, black at the tips. Hairs on the head comparatively scarce, somewhat denser on the body. Head oval, tapering towards the anterior margin, the greatest width behind the middle; no fontanelle visible. Labrum oval, anteriorly rounded. Mandibles short and powerful, the left one with 3 distinct saw teeth in the basal part, the anterior one being inserted nearly in the middle of the mandible. Antennae 16- or 17-jointed. When 16-jointed, the 3rd joint is slightly shorter than

the 2nd, and the 4th joint shorter than the 3rd. When there are 17 joints, the 3rd one is divided in two, which together are shorter than the 2nd joint. The anterior edge of pronotum is high and in the middle distinctly incised with a longitudinal furrow; posterior edge without incision but with a furrow.

Length of body	...	...	...	...	4.81-5.29 mm.
Length of head with mandibles	...	...	...	...	2.08-2.37
Length of head without mandibles	...	...	...	...	1.38-1.59
Width of head	...	...	...	...	1.09-1.38
Width of pronotum	...	...	...	...	0.86-1.00

Worker.—Only one worker was found in the collection, and it is an open question whether it belongs to the same species. It is larger than the large worker of *obscuriceps* described by Holmgren, the soldier of the present species being, however, considerably larger than those of *obscuriceps*; this is only what one would expect.

Head quadrangular, rounded, light brown, with lighter convex clypeo-basal. Antennae 18-jointed, 3rd joint longer than the 4th. Anterior edge of pronotum high, with median incision and furrow....

Length of body	...	...	...	...	5.00 mm.
Width of head	...	...	...	...	1.52
Width of pronotum	...	...	...	...	0.88

This species is undoubtedly closely related to *obscuriceps*, Wasm. The latter, as described by Holmgren in his monograph (Termiten Studien, iv, p. 141), differs, however, distinctly from *marshalli*, which is characterized by the greater size of the soldiers, the teeth of the left mandible and the shape of the pronotum. It is true that Wasmann in the original description (Zool. Jahr., Abt. f. Syst. xvii, 1902, p. 113) of *obscuriceps* says that the pronotum has an anterior median incision "tief ausgeschnitten," just as in the present species. But Holmgren, who has examined the type specimens of Wasmann, does not mention any incision. It is therefore possible that Wasmann's material also contains the species here described. From Wasmann's description *marshalli* differs, in addition to its large size, by the number of the joints of the antennae.

CEYLON: Avisavella, 2.viii.1922, "nest in ground," and "bamboo fence"; Ral-tota, 29.v.1922, "dead stump of *Grevillea*."

12. *Eutermes ceylonicus*, Holmgr. (1911).

This identification is based on an examination of specimens named by Holmgren. The measurements agree fairly with those given by him in his monograph (v, p. 177), although there are slight variations. Holmgren's measurements differ, by the way, from those that he gives in the original description, which he has evidently found to be inexact.

Soldier.—

Length of body	...	...	...	...	2.88-3.55 mm.
Length of head with nose	...	...	...	...	1.41-1.48
Length of head without nose	...	...	...	...	0.88-0.95
Width of head	...	...	...	...	0.74-0.90
Width of pronotum	...	...	...	...	0.40-0.46

Workers.—

Large.

Length of body	...	...	...	...	3.94-4.32 mm.
Width of head	...	...	...	...	0.99
Width of pronotum	...	...	...	...	0.46-0.53

Small.

Length of body	...	...	...	...	3.84 mm.
Width of head	...	...	...	...	0.81-0.92
Width of pronotum	...	...	...	...	0.53

CEYLON: Pelmadulla, 13.x.1922, "from galleries and bark of tea bush," "reported ringbarking tea stem," "dead wood of tea"; Raltota, 29.v.1922, "dead portion of dadap stem."

13. *Eutermes ceyloniellus*, sp. n.

Imago.—Head dark chestnut-brown; anterior part, clypeo-basal, labrum lighter. Mouth-parts and antennae lighter; the latter darker towards the tips. The tips of the mandibles black. Pronotum brown, as are also the other tergites of the body. The sternites are lighter in the middle. Wings yellowish-brown, with a somewhat darker line along the subcosta. Head and pronotum and other parts of the body with numerous hairs except on the wings.

Head oval, greatest width on a level with the eyes, which are rather small, the diameter about equal to the length of the clypeo-basal. Ocelli rather large, directed obliquely forwards and placed at a distance from the eyes equal to their own greatest diameter. The fontanelle appears as a small oval projection in the middle of the frons. Clypeo-basal somewhat convex, rather short, its width slightly exceeding its length. Antennae 15-jointed; 2nd joint twice as long as and considerably broader than the 3rd joint; 4th joint from one and a half times to twice the 3rd joint.

Anterior margin of pronotum slightly concave, posterior margin rounded in an even curve. Mediana of the anterior wing not distinctly discernible, branching off in the distal third in a couple of small branches; cubitus with 9–10 branches, the basal ones being thick and slightly brown-coloured, while the distal ones are indistinct.

Length with wings	...	...	...	...	13.00 mm.
Length without wings	...	...	...	...	6.00–7.20
Length of the anterior wings	...	...	...	...	11.50
Width of head	...	...	...	...	1.16–1.25
Width of pronotum	...	...	...	...	1.13
Length of pronotum	...	...	...	...	0.63

The present species differs in several characters from the species of *Eutermes* already known from Ceylon, such as the arrangement of the ocelli and the joints of the antennae. On the other hand, it is undoubtedly closely related to *E. singaporiensis*, Hav. From this one might draw the conclusion that *E. ceyloniellus* is possibly the imago of *E. ceylonicus*, Holmgr., the soldier of which greatly resembles that of *E. singaporiensis*. As there is no clear evidence for this I have provisionally described the imago as a new species.

CEYLON: Badulla, 17.viii.1914, "stem and roots of tea."

14. *Eutermes (Trinervitermes) rubidus*, Hag. (1860).

The only specimens of the subgenus *Trinervitermes* present in the collection seem to belong to the old species *rubidus* of Hagen, although the size differs rather considerably from the specimens described by Holmgren (*Termiten Studien*, iv, p. 192). It is, however, well known that the size of the species of the genus *Eutermes* is very variable. In other respects my specimens agree very well with the description by Holmgren. Another circumstance which points in the same direction is that my material was collected in the same locality, Colombo, from which Nietner brought home the material described by Hagen.

Two kinds of soldiers and one kind of worker are to be found in the present collection. The soldiers especially are larger than those described by Holmgren.

<i>Large Soldier</i> —				Acc. to Holmgr.	Present material.
Length of body	...	...	...	2.70–3.50 mm.	4.00–4.52 mm.
Length of head with nose	...	...	...	1.90–2.13	2.23–2.30
Length of head without nose	...	...	...	1.03–1.10	1.31–1.34
Width of head	...	...	...	0.91–1.10	1.16–1.20
Width of pronotum	...	...	...	0.49–0.61	0.56

Small Soldier—

Length of body	...	...	...	3.00 mm.	— mm.
Length of head with nose	...	...	...	1.41	1.48–1.53
Length of head without nose	...	...	...	0.65	0.85
Width of head	...	...	...	0.61	0.56–0.60
Width of pronotum	...	...	...	0.42	—

From a comparison of the measurements it is evident that the greatest difference is in the size of the head. On the other hand, the size of the head can be measured in different ways, and it is a matter of opinion as to where to draw the line between the head proper and the nose. The more definite measurements, the entire length and the width of the head, are not subject to such great variations as to give sufficient grounds for establishing a new species, considering that my specimens in other respects agree well with *rubidus*, Hag. Moreover, the present material is not in a good state of conservation.

CEYLON: Colombo, 17.x.1922, "grass lawn."

15. *Microcerotermes bugnioni*, Holmgr. (1911).

The collection contains some wingless imagines, soldiers and workers of this species, which agree very well with Holmgren's description, although some small differences in size occur.

Imago.—These are longer than the type specimens, probably owing to the fact that they are quite young and soft and have become somewhat swollen in preservation; the other dimensions are smaller.

Length without wings	...	...	...	5.38–5.58 mm.
Length of the anterior wings (lost)	...	...	...	6.25
Width of head	...	...	...	0.79
Width of pronotum	...	...	...	0.61
Length of pronotum	...	...	...	0.38

Soldier.—Besides a soldier of quite normal size there is another dwarfed specimen, which in size resembles *M. greeni*, but which on account of the teeth of the mandibles must be referred to *bugnioni*.

	(Normal.)	(Deformed.)
Length of body	4.9 mm.	4.71 mm.
Length of head with mandibles	2.37	2.08
Length of head without mandibles	1.59	1.34
Width of head	0.81	0.77
Width of pronotum	0.53	0.49

Worker.—The dimorphism of the workers mentioned by Holmgren (*Termiten Studien*, iv, p. 259) is evident in the present material. The head of the large worker is quadrangular, with rounded angles and comparatively great width; its antennae

are 13-jointed, with a small 4th joint. The head of the smaller worker, on the other hand, is oval, elongated, with less strongly chitinized cuticle; its antennae are also 13-jointed, with a small 4th joint, which, however, sometimes is longer even than the 2nd joint and shows indications of a division in the middle, which if developed would have resulted in the antennae having 14 joints.

				Large worker.	Small worker.
Length of body	...	...	...	3.94-4.50 mm.	3.75 mm.
Width of head	...	...	...	0.82-0.85	0.70
Width of pronotum	...	...	...	0.47-0.49	0.42

CEYLON: Akkara-ipaltu, 6.iii.1922, "dead bark of coconut."

16. *Microcerotermes greeni*, Holmgr. (1913).

The soldier, especially, of this species is easily distinguished from *M. bugnioni* by the teeth of the mandibles. The specimens of the present collection are slightly larger than those described by Holmgren, the length of the head being about 2 mm.

Soldier.—

Length of body	...	...	...	...	4.23-4.52 mm.
Length of head with mandibles	...	...	...	...	1.98-2.08
Length of head without mandibles	...	...	...	...	1.27-1.41
Width of head	...	...	...	...	0.81
Width of pronotum	...	...	...	...	0.53

CEYLON: Elpitiya, Ambalangoda, 21.iii.1923, "nest among roots of dead tea."

17. *Capritermes hutsoni*, sp. n.

This genus is only represented by one species, and that a new one easily distinguished from others of this genus from Ceylon.



Fig. 5. *Capritermes hutsoni*, Kemn., sp. n.

Soldier.—Head comparatively short and broad, dorsoventrally depressed, fontanelle small, puncture-shaped. Labrum of the usual obliquely twisted shape, anteriorly with a rather deep median incision and long lateral angles. Left mandible nearly as long as the head, obtusely truncated at the tip, not pointed as in *ceylonicus*, Holmgr., or bent inwards like a beak, as in *incola*, Wasm. (comp. photographs in

Escherich's Termitenleben auf Ceylon, pl. ii, figs. Q and R). Antennae long, measuring 2.30 mm., 14-jointed,* with joints 2, 3 and 4 subequal. Hind tibiae 1 mm. long.

Length of body	...	...	...	...	5.96-6.00 mm.
Length of head with mandibles	...	...	...	...	3.80-4.00
Length of head without mandibles	...	...	...	...	1.98-2.05
Width of head	...	...	...	...	1.16-1.23
Width of pronotum	...	...	...	...	0.70-0.77

Worker.—Head broadly oval, flat, fontanelle very conspicuous, forming an oval depression with a flat bottom. Clypeo-basal large, fairly convex. Antennae 14-jointed; 3rd and 4th joint subequal, a little shorter than joint 2. Anterior margin of pronotum without incision.

Length of body	...	...	...	...	4.30-4.50 mm.
Width of head	...	...	...	...	0.99
Width of pronotum	...	...	...	...	0.53

As already pointed out, the soldier of this species is easily distinguished from other species from Ceylon by the shape of the labrum and the left mandible, as well as by its size. It resembles *C. obtusus* described by Silvestri (1923) from Barkuda Island in Chilka Lake, India, which is, however, of different size, with shorter antennae and longer posterior tibiae.

CEYLON: Pelmadulla, 13.ix.1922, "roots of tea."

* The same number of joints is sometimes also found in the antennae of *ceylonicus*, Holmgr., which H. describes as 13-jointed, as I have ascertained by examining his type specimens.

THERESIA AMPELOPHAGA, BAYLE, IN CRIMEAN VINEYARDS.

By S. M. FEDOROV,

Entomological Section, South-Crimean Station for Plant Protection.

(PLATES XX-XXI.)

Theresia (Procris) ampelophaga, Bayle, a moth of the family ANTHRO CERIDAE (ZYGAENIDAE) is one of the most important pests of the vine in various countries, but the existing accounts of its bionomics are very contradictory and not free from inaccuracies.

In Crimea this pest had already been observed early in the eighteenth century by Pallas, who has given a very good description of the larva, though he did not give it a scientific name. It was recorded again in 1862, and in 1895-97, while since 1912 its injuries have attracted the special attention of the local entomological organisations; but all these bionomic observations were made only occasionally and partly under artificial conditions, so that there is no assurance as to the correct interpretation of the life-history of the pest in nature. This induced the author to undertake, during the year 1924, more systematic observations on the pest in its natural surroundings with the view of obtaining data necessary for a detailed experimental study.

Distribution and Ecology.

It is interesting to note that *Th. ampelophaga* occurs only in the southern coastal districts of Crimea. Observations of previous writers, as well as our own, refer all to the districts of Magaratch (east of Yalta), Alushta, Sudak, Taraktam and Otuzy. These localities represent the local centres of the pest, where it is always present in numbers; both westwards and eastwards from this area the moth is rare, or even absent. It is unknown also from the vineyards of the steppe parts of Crimea, and even from those on the northern slopes of the Crimean mountains.

The ecology of *Th. ampelophaga* will be clear after the following brief description of its Crimean habitat.

The experimental plot where the observations of 1924 were conducted was at Verkhny Magaratch, a couple of miles east of Yalta, on the southern slope of mountains, about 90 metres above sea-level. The climate of the place is characterised by an average barometric pressure of about 760 mm., and an average annual temperature of 12.5° C., with a maximum of 30.5° C. in July, and a minimum of -9.30° C. in December. These figures are for 1924. Usually, however, January is the coldest month, and temperatures increase from January until July, when the curve begins to decline. The rainfall for 1924 was 480 mm. The soil of the experimental plot was heavy clay, with a considerable admixture of lime and stones, very difficult for digging. A number of weeds were growing between the vines.

Another area of permanent habitation of *Th. ampelophaga* in Crimea is the Sudak valley, with its prolongations, the valleys of Taraktash and Aisan. The climate of these localities is characterised by a mean annual temperature (for 10 years) of 12.6°C., July being the hottest month (23.9° C.), and February the coldest (1.5° C.). The rainfall averaged for the period of 10 years 333 mm., and this relatively small amount is responsible for the desert-like vegetation of higher slopes; while in the valleys where the vineyards are, water coming down the slopes during the rains makes good the deficit.

This latter area is mainly occupied by small peasant vineyards, in which there is no regular planting in rows, nor are all the usual improved methods of cultivation employed, which makes it the chief centre of distribution of the pest.

The general characteristics of the habitat conditions of *Th. ampelophaga* in Crimea, as illustrated by the above descriptions of its main areas, appear to be as follows. The moth inhabits mainly valleys amongst mountains, with a considerable amount of precipitation, but it actually lives on their dry slopes, where the vineyards are mainly concentrated. The temperature data, given above, indicate that an average total of temperatures amounting to 2,300° C. during the season, from April to the middle of August, is necessary to produce a single generation a year. This seems to indicate that not all localities suitable for the cultivation of vine are favourable for the insect.

Bionomics of the Pest.

Towards the end of March, or early in April, the larvae of the 3rd-4th stage, about a centimetre long, emerge from their winter quarters inside the vines cut last year, or under the bark of old vine-stems. The date of emergence depends on conditions of weather, and on the degree of development of the vines.

At first the larvae feed on the buds, then on the young leaves. They are most active in the morning and again in the evening, when they may be seen on the leaves, while during the heat they hide under them, which they do also during rain, strong wind, etc.

Towards the end of May, or the beginning of June the larvae reach their full growth and look for places in which to pupate. Pupation occurs on old vines under the bark, but often the larvae leave the plant altogether and pupate on some other trees, growing near by, under the bark, in cracks, or else under stones, amongst fallen leaves, in cracks of the soil and such like places (Pl. xxi, figs. 3-5).

Before pupation the larva is very restless and crawls about very quickly. When a suitable place is found, the larva makes first a loose and fine web which it fastens to edges of its hiding place. After that it begins to make a more dense cocoon, but only 6-7 days after the cocoon is made does actual pupation take place.

The pupal stage takes about four weeks. At first the pupa is pale-coloured, but early in the fourth week it becomes darker, and about 5 days before the moth emerges the pupa assumes a deep blue-black colour.

The moths (Pl. xx, fig. 1) in nature appear after the 20th of June up to about the 10th of July, there being very noticeable periodic fluctuation in the numbers of emerging moths. In 1924 the emergence of moths began on 16th June, the numbers increasing daily up to the 20th, when the curve went downwards, and after the 29th no moths emerged until July 7th, when a new period began, which did not last long, and the moths were not as numerous as during the first period. The moths emerge early in the morning, between sunrise and 8-9 a.m., and they are most active during these early hours, while later in the day they become less so, and towards noon all signs of activity disappear. The freshly-emerged moths sit on any plants, drying and unfolding their wings (Pl. xx, fig. 3), which lasts about 25-30 minutes. The males emerge usually before the females and begin to fly about while the females are still drying their wings. Copulation takes about 3-5 hours, and after it a female may start laying its eggs very soon, but in some cases no egg-laying was observed until the evening, or even the next day. The moths do not feed in nature, and they have never been observed on flowers. They live about a week, but are most active only during the first days of their life.

For laying its eggs, a female usually selects a vine plant, and the eggs are laid in clusters on the underside of the leaves, near the median vein (Pl. xx, figs. 2,4). The

number of eggs in a cluster averages 50–70, but it varies from 30 to 120. One female may lay as many as 500–600 eggs, in several clusters placed on several leaves. The eggs are sometimes laid also on the upper side of the leaves, but this happens seldom, and only in well-shaded places. We found eggs also on certain weeds, *e.g.*, on leaves of *Psarolea bituminosa*, L., but the larvae which emerged from these eggs at once dropped by silk threads on to vines.

The larvae (Pl. xx, fig. 1) in nature emerge after 10–12 days. Immediately after hatching out they disperse all over the vine plant. They are absolutely monophagous, feeding on nothing but vine leaves. The first injuries by the young larvae are like punctures, which gradually grow in dimensions (Pl. xxi, fig. 1.) The larvae crawl on the upper surface of the leaves, and only during the heat of the day do they hide under them. They are most active at sunrise, becoming less so during the hot time of the day. In this way they live until the first days of August and undergo during this period 2–3 moults, according to the date of hatching and the amount of food. Then they begin to look for places suitable for hibernation. Some of them find their winter-quarters in cracks of bark of old vines, but the majority burrow into the centre of vine stems cut the year before (Pl. xxi, fig. 2).

Thus, under the conditions of South Crimea, *Th. ampelophaga* has only one generation a year, while in Southern Italy there are two, and the pupa of the second generation hibernates. In south-eastern France (Mayet), where there is one generation, the winter is passed in the egg-stage. Records from Bessarabia and from various localities in the Caucasus also refer to a single generation, with one exception, namely, Barberon,* who says that there are two generations on the Black Sea coast of the Caucasus, but this must be a mistake due to observations under artificial conditions.

A comparison of our data with the records in literature show that the imago does not live long anywhere, though the moths may be in evidence during a whole month, owing to the protracted period of their emergence from the pupae.

The egg-stage lasts everywhere about 10–12 days, but hibernation may extend this period (S.E. France). The larval stage takes 23–28 days, or up to 300 days in the case of hibernating larvae, which undergo a long period of rest, or diapause. The pupal stage is normally 10–15 days, or up to 270 with a diapause.

Under any climatic conditions, however, one remarkable phenomenon in the life-history of *Th. ampelophaga* may be observed—towards the period of ripening of the grapes the larva either completes its development and pupates, or else (as occurs in Crimea) the larva after 2–3 moults, but not yet fully-grown, undergoes a diapause until the next spring.

This larval diapause of *Th. ampelophaga* is very interesting, because it throws some light on factors which may be responsible for similar phenomena generally. Indeed, if a diapause in the egg, or in the pupa, may be due to climatic conditions, this is obviously not the case with the larva, in which the interruption of development is clearly due to the influence of food, as the following evidence indicates.

According to observations of the Viticultural Section of the local Botanical Gardens, the development of the vine plant in 1925 took place in the following manner :—

Buds beginning to fill up	24.iii–7.iv.
Buds open	9.iv–25.iv.
Beginning of flowering	2.vi.–15.vi.
End of flowering	15.vi.–29.vi.
Beginning of ripening of grapes	3.viii.–14.viii.

* Vvestnik Vinodeliya, 1906, No. 6, pp. 342–348.

If these phenological data are compared with those in the life-history of *Th. ampelophaga* the following correlations may be noticed. The emergence of the larvae from hibernation at the end of March, or early in April, coincides with the filling up of the buds. Larvae live until June, that is during all phases of appearance and development of the leaves up to the flowering period. The end of the latter and the formation of the young fruit is the time when a new generation of larvae appears, and these feed on the leaves until the middle of August, when the ripening of the grapes commences and the larvae leave the vines to look for suitable places for hibernation. These two phenomena, *viz.*, the beginning of the ripening of the grapes and the end of the feeding period of the larvae, are so closely connected with each other that their relation must be that of cause and effect. Indeed, no other factors (temperature, moisture, light) can possibly account for this sudden change in the behaviour of the larvae, and the only possible explanation is that the process of ripening of the grapes coincides with some change in the chemical constitution of the leaves, most probably in the starch and its derivatives. This conclusion will be checked next year by direct experiments.

Nature of Damage.

Th. ampelophaga damages vines from the early spring when its larvae make small holes in the buds and, burrowing into them, excavate them from inside. This kind of injury is most serious, as a damaged bud means destruction of a whole fruit-bearing shoot.

Later on, the larvae begin to injure the leaves, which they skeletonize (Pl. xxi, fig. 1). A heavily injured vine does not develop buds, or only very few, so that it bears practically no fruit. Moreover, the vine becomes deformed and weak, and often looks as though it were dead. Our observations show that such complete injury (100 per cent.) to a vine is caused by 10–12 larvae living on it, while even 3–4 larvae reduce its productivity by 40–50 per cent., and only the vines harbouring not more than one or two larvae remain sufficiently vigorous to bear fruit. Such less injured vines, however, are liable to fresh attacks at the beginning of July by the larvae of the next generation, which skeletonize the leaves. This damage is, of course, less important to the plant than that caused to the buds, but it has a serious effect on a weakened plant.

The insect lives in vineyards in more or less concentrated colonies, which are marked by groups of defoliated and dying vines. It is interesting that these centres of infestation are usually surrounded by practically, or entirely, healthy vines, which shows that the insect is but little able to spread, except perhaps in the adult stage.

As regards the varieties of vine injured, *Th. ampelophaga* was observed in Crimea on the wild form of *Vitis vinifera*; in some localities it was even found in enormous numbers on wild vines, while the vineyards were free from it. Amongst the cultivated varieties, the muscatels are most preferred by the pest, particularly *Muscat violet* and *Kakour blanc*. Among varieties of *Vitis labrusca* the *Isabella* has been found to suffer from the pest.

As for conditions in vineyards favourable to the pest, the following may be observed.

Presence of weeds in a vineyard is obviously favourable to the insect, since the larvae which happen to fall from a vine climb to another by means of the weeds, and the copulation of the moths takes place, according to our observations, more often on weeds than on vines.

It is noticeable also that the numbers of the pest are greater in vineyards in which there are many old vines and dead vine-stumps providing places for pupation and hibernation of the larvae.

Further factors favourable to the insect are the irregular planting of vines (not in rows) and growing them without supports; vines spreading on the ground are usually badly infested by the insect.

Such defects in viticultural practice are not now to be found in the larger vineyards of Crimea, but they are still very serious in the small vineyards belonging to peasants. These, the poorer vinegrowers, are therefore suffering most from the pest.

Control Measures.

The best period for applying control methods against *Th. ampelophaga* in Crimea is autumn and winter, when the majority of larvae are hibernating inside the remaining portions of the cut shoots. These must be all cut down to the first knot (Pl. xxi, fig. 2). Some larvae hibernate in cracks in the bark of old vines, and it is necessary to remove all loose bark. All the shoots cut off and the bark must be burnt. It is very important that fences in vineyards should never be made of old vines or other materials in which larvae may easily find suitable places for hibernation.

Regular digging up of the soil in vineyards is also of importance, not only as a measure generally useful for the more vigorous growth of the vines, but also as a direct method of control of the pest, since a considerable number of larvae pupate in cracks in the soil, and digging it up prevents the emergence of the moths.

In spring, spraying with insecticides is necessary, barium chloride (3 per cent. solution) being the most suitable poison; the addition of black molasses, 1 lb. to 16 gallons, increases the adhesiveness of the spray. Paris green may also be used. The best periods for spraying are when the buds are filling up, which occurs in Crimea at the end of March or early in April, and also when the leaves are fully opened, that is, later in April.

The injuries inflicted during July and August are less dangerous for the vine, but spraying with barium chloride may be applied then again, if necessary.

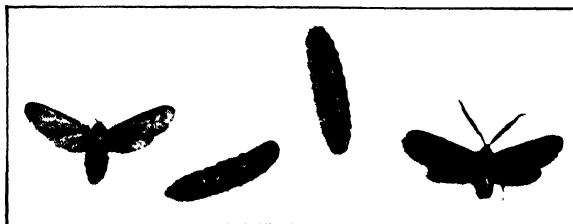


Fig. 1 Female, larvæ and male

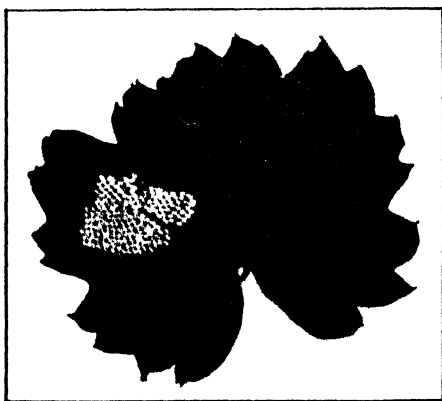


Fig. 2 Cluster of eggs on vine leaf

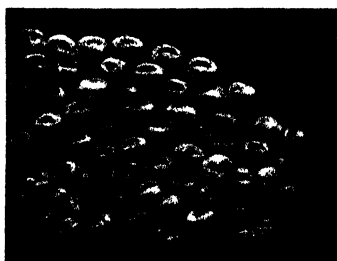


Fig. 4. Eggs enlarged.



Fig. 3 Moths drying their wings after emergence.



Fig. 1. Vine damaged by larvae



Fig. 2 Showing how the vine branches should be cut



Fig. 3. Cocoons on bark



Fig. 4. Cocoons under stone.



Fig. 5. Cocoons under dead leaves on ground.

Theresia (Procris) ampelophaga, Bayle, a pest of the grape-vine in Crimea.

ON THE *MINUTUS* GROUP OF THE GENUS *PHLEBOTOMUS* IN PALESTINE.

By S. ADLER & O. THEODOR,
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From June 1925 to December 1925 a number of *Phlebotomus*, considered at first to be *Phlebotomus minutus*, Rondani (1843), were collected in Jericho. As Austen (1921) had recorded *P. minutus* var. *africanus*, Newstead (1912), from the Jaffa district and Buxton (1924) had recorded *P. minutus* only from Haifa and Jerusalem and did not find among his material any specimens with the palpal formula of *P. minutus* var. *africanus*, we commenced a systematic examination of our material with particular reference to palpal characters in order to determine whether any varieties of *P. minutus* occur in Jericho.

We found that sandflies with the following palpal formulae were present :—

(A) 1, 2, 4, 3, 5—i.e., the palpal formula of *P. minutus*. Sandflies with this palpal formula appeared towards the end of June and disappeared early in November.

(B) 1, 2, 3, 4, 5—i.e., the palpal formula of *P. minutus* var. *africanus*. Sandflies with this palpal formula appeared towards the end of June and were present till December. From October onwards this type was much more common than the first.

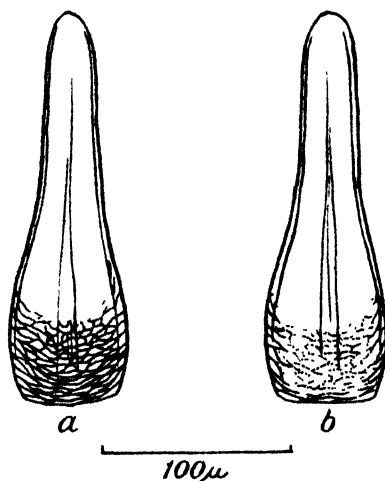


Fig. 1. Pharynx of: (a) *Phlebotomus papatasi*; (b) *P. perniciosus*.

(C) 1, 2, (3, 4), 5—2 being almost two-thirds of 3. Only one specimen, a female, with this formula was captured on 6th December 1925.

Further examination revealed the fact that these three types cannot be regarded as varieties of a single species but are indeed three very definite species and, as we shall show, differ very markedly in their internal morphology.

The identification of female specimens of the genus *Phlebotomus* is admittedly difficult and rests mainly on palpal formulae, which are troublesome to determine, on the size relationship between various antennal segments, particularly segments 3, 4 and 5, and 12–16 inclusive (15 and 16 being frequently broken), and on wing characters. Recently Sinton (1925), realising the difficulty of the specific determination of female *Phlebotomus*, has undertaken an examination of the hypopygium, but

without finding "features of the same primary diagnostic importance as have been yielded by the same structure in the male."

In this paper we wish to point out the diagnostic importance of the pharynx, buccal cavity and spermathecae in the diagnosis of the females of the *minutus* group, and particularly of the pharynx and buccal cavity, for the character of the spermathecae cannot be accurately determined without dissection, whereas the other

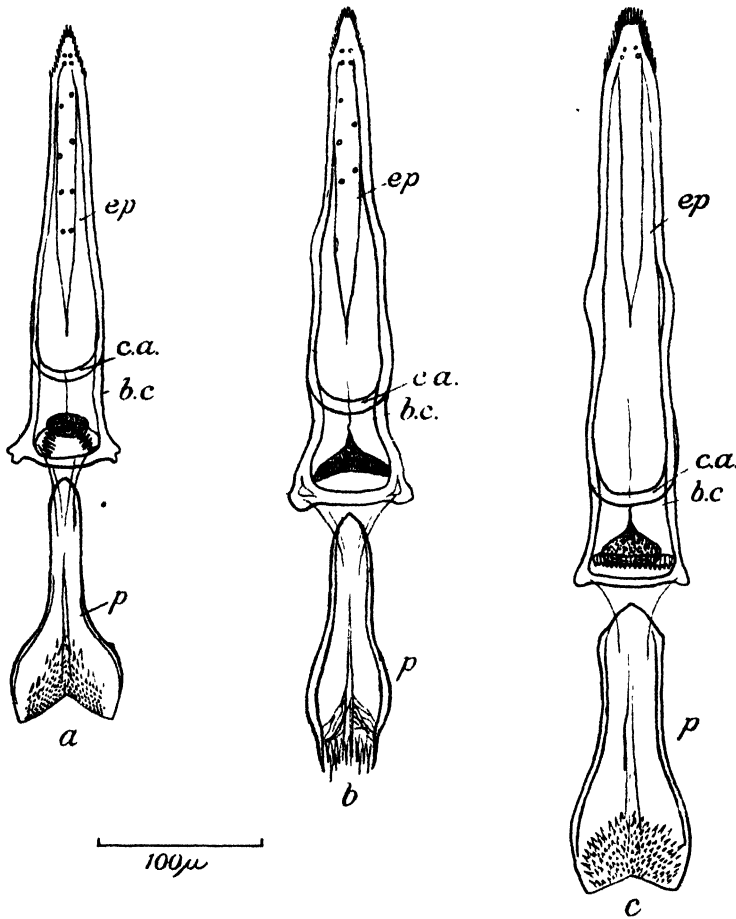


Fig. 2. Pharynx (*p*), buccal cavity (*b.c.*), epipharynx (*ep*) and chitinous arch from which salivary muscle arises (*c.a.*) in (a) *Phlebotomus minutus*, ♀; (b) *P. africanus*, ♀; (c) undetermined ♀.

characters can be readily determined in uncleared specimens, examined in saline, even in such a large species as *Phlebotomus papatasi*. Possibly the characters of the pharynx and buccal cavity combined, or even the pharynx alone, may prove to be of diagnostic value throughout the whole genus, for *P. papatasi* and *P. perniciosus* can be distinguished from each other by an examination of the pharynx (fig. 1 a, b).

The pharynx is composed of three chitinous plates, one dorsal and two infero-lateral. Posteriorly all the three plates are toothed for a varying distance; viewed from above or from below the teeth appear in optical section as a network of lines (e.g., in *P. papatasi*, fig. 1, a) as points (e.g., in *P. perniciosus*, fig. 1, b) or as definite teeth (e.g., *P. minutus* ♀, fig. 2, a).

The buccal cavity is also composed of three plates, one inferior, which forms the floor of the cavity and is directly continuous with the hypopharynx, and two superior lateral plates, which form the roof of the buccal cavity and are directly continuous with the epipharynx. The two superior plates fuse in the middle line, and the line of fusion can be clearly seen in specimens examined in saline. Laterally the backward continuations of the epipharynx and hypopharynx fuse and form the lateral margins of the buccal cavity. From the backward continuation of the margins of the epipharynx a chitinous bar passes upwards and backwards; turning downwards under the floor of the buccal cavity the two bars meet in the middle to form a chitinous arch (fig. 2, *a*, *b*, *c*), which is a conspicuous feature in the anatomy of the head. This arch during the whole of its length serves as an origin for the muscle which is inserted into the salivary pump.

The salivary pump lies between two horizontal laminae of the hypopharynx, a superior lamina which forms the floor of the buccal cavity and an inferior lamina which is directly continuous with the lower surface of the common salivary duct. The salivary pump is also quite evident in an examination of undissected heads in saline. In *P. papatasi* and in *P. perniciosus* the floor of the salivary pump bears teeth.

The posterior part of the floor of the buccal cavity of the *minutus* group bears teeth (figs. 2, 3, 4), and the arrangement of these teeth is probably of diagnostic value, for they are constantly present in males and females. In addition, the posterior dorsal part of the buccal cavity contains a pigmented area which is nearly always present in the female and is occasionally present in the male. The buccal cavity of *P. papatasi* and *P. perniciosus* contains no teeth and no pigmented area.

An examination of females with the palpal formula considered characteristic of *P. minutus* shows certain constant features of the spermathecae, pharynx and buccal cavity, and since the characteristics of the pharynx and buccal cavity are easier to determine than the palpal characters (the third segment may be only 5 μ longer than the fourth), we suggest their substitution in the diagnosis of this species. Females with the palpal formula ascribed to *P. minutus* var. *africanus* show characteristic features of the spermathecae, pharynx and buccal cavity that are strikingly and constantly different from the corresponding parts of *P. minutus*. The former cannot, therefore, be maintained as a variety and must be raised to the rank of a distinct species with the name *Phlebotomus africanus*. The fact that so distinguished an entomologist as Newstead considered *P. africanus* a variety of *P. minutus* on the grounds of external characters, mainly palpal formula, conclusively proves the inadequacy of the latter in the specific diagnosis of sandflies of the *minutus* group.

The third type of palpal formula mentioned above was found associated with spermathecae, pharynx and buccal cavity quite different from those of *P. minutus* and *P. africanus*. We cannot identify or name this species, for we have not had the opportunity of examining other members of the *minutus* group apart from *P. africanus* and *P. minutus* with reference to spermathecae pharynx and buccal cavity, and we shall refer to it later as an undetermined species.

There is not unfortunately the same correspondence between palpal formula and structure of the pharynx and buccal cavity in the males as in the females. Usually the palpal formula of *P. minutus* is associated with a definite type of pharynx and buccal cavity and the palpal formula of *P. africanus* with another type of pharynx and buccal cavity, but there are exceptions, e.g.: one ♂ in which the fourth segment of the palps was larger than the third was associated with a pharynx and buccal cavity suggestive of *P. minutus*; one ♂ in which the fifth segment of the palp was short (the measurements of the various segments are 29 μ , 35 μ , 109 μ , 104 μ , 133 μ), and a diagnosis of *P. bedfordi* might have been made, but the pharynx and buccal cavity suggested *P. africanus*. It appears, therefore, that the palps of the males

are subject to variations, and a revision of the males of the *minutus* group is advisable on the basis either of internal structure or on a closer analysis of the external genitalia than is at present extant.

In this paper males are named *P. minutus* or *P. africanus* according to the character of the pharynx and buccal cavity.

***Phlebotomus africanus*, Newst.**

♀. The spermathecae (fig. 5, *a*) are heavily chitinised, non-segmented structures leading into a narrow duct; the ducts of the two spermathecae unite to form a short common duct a little before their exit. Length of spermatheca to breadth, 2 : 1.

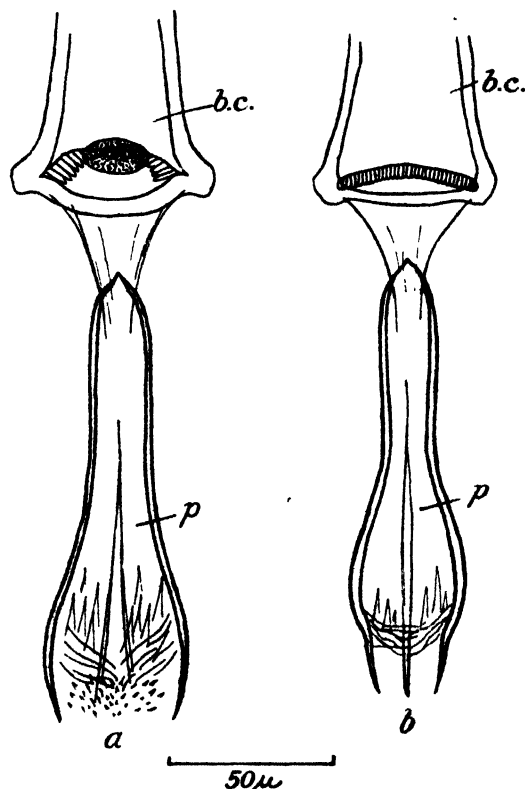


Fig. 3. Pharynx (*p*) and part of buccal cavity (*b.c.*) of: (*a*) *Phlebotomus minutus*, ♂; (*b*) *P. africanus*, ♂.

The pharynx (fig. 2, *b*) is narrow anteriorly, and the sides terminate posteriorly in two short narrow processes; the teeth are not prominent. Posteriorly the widest part of the pharynx is twice as wide as the anterior part.

The buccal cavity (figs. 2, *b*; 4, *b*) shows posteriorly a heavily pigmented area triangular in shape, the apex being anterior and the base concave. In addition, the posterior part of the buccal cavity contains a toothed area, the teeth being parallel and point backwards. The pigmented area may rarely be only lightly pigmented, and in specimens cleared in potash may not be visible, but the teeth are constant.

♂. The pharynx (fig. 3, *b*) is similar to that of the female, but narrower, and the teeth even less prominent; the sides terminate posteriorly in two short narrow processes.

The pigmented area on the buccal cavity is nearly always absent, but the toothed area is constant and the teeth show the same character as in the female (fig. 3, b).

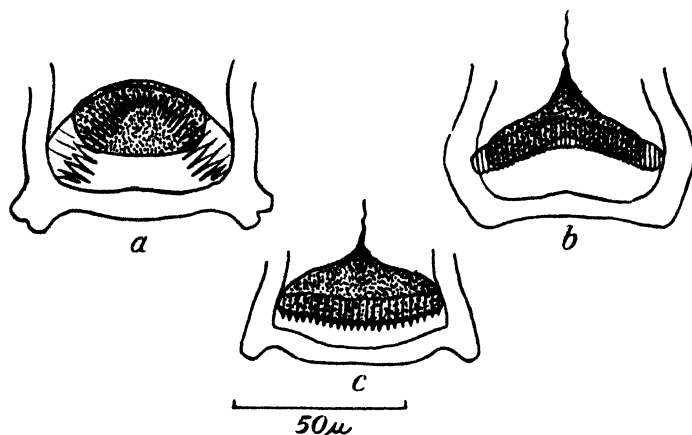


Fig. 4. Posterior part of buccal cavity showing teeth and pigmented area of : (a) *Phlebotomus minutus*, ♀; (b) *P. africanus*, ♀; (c) undetermined ♀.

***Phlebotomus minutus*, Rond.**

♀. The spermathecae (fig. 5, b) are strikingly different from those of *P. africanus*; they are tubular, non-segmented, not so heavily chitinised, and open directly into a common duct. Length of spermatheca to breadth, 5 : 1.

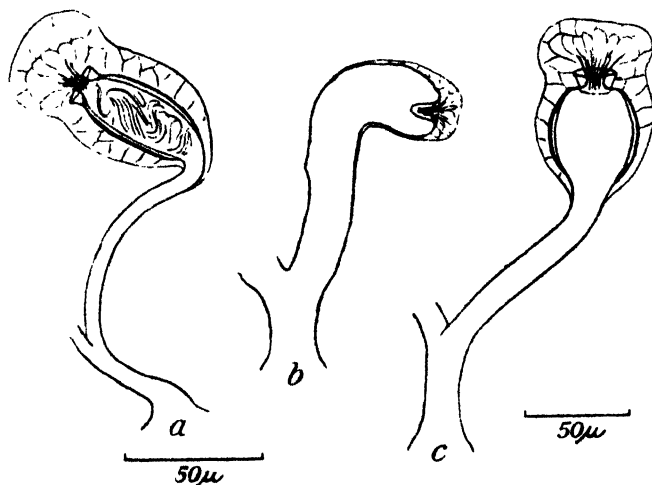


Fig. 5. Spermathecae of : (a) *Phlebotomus africanus*; (b) *P. minutus*; (c) undetermined species.

The pharynx and buccal cavity (fig. 2, a) offer a ready means of distinguishing this species from *P. africanus*. The pharynx is narrow in its anterior two-thirds and posteriorly comparatively very broad, its shape being entirely different from that of *P. africanus*; the broadest part of the pharynx posteriorly is four to five times as broad as the anterior part; the teeth are strikingly more prominent than those of the former species. The posterior border of the pharynx is strongly indented.

The pigmented area of the buccal cavity (figs. 2, a; 4, a) is elliptical in shape and is usually but not constantly present. There is a toothed area, as in *P. africanus*;

the teeth are placed on a concave arc and point backwards and towards the centre of the arc.

♂. The pharynx (fig. 3, *a*) differs markedly in shape and appearance from that of the female, being much narrower (the widest part is a little more than twice the width of the anterior part); the teeth are not prominent. It is wider than the pharynx of *P. africanus* and does not terminate laterally and posteriorly in two narrow processes.

The pigmented area of the buccal cavity (fig. 3, *a*) is frequently absent, but when present is elliptical in shape as in the female. The toothed area of the buccal cavity is constantly present and has the same character as that of the female, but the arc on which the teeth stand is not so concave.

It will be seen from the above description and from the diagrams that the pharynx of the males of *P. africanus* and *P. minutus* has not the same diagnostic importance as in the females, but the toothed area of the buccal cavity serves to distinguish these two species; this is important, for the external genitalia of the males of *P. africanus* and *P. minutus* are very similar.

Phlebotomus sp.

Only one specimen, a female, was found.

Size, 2.2 mm.; head, 360μ ; epipharynx, 147μ ; palpal measurements: segment 1= 50μ , 2= 80μ , 3= 128μ , 4= 128μ , 5= 267μ .

Antennae having the fourth to fifteenth segments inclusive with paired geniculated spines. Measurements of antennal segments: 3= 180μ ; 4= 108μ ; 5= 92μ ; 6= 96μ ; 12-16= 267μ .

Wings (fig. 6). Length, 1680μ ; greatest breadth, 450μ ; $\alpha=200\mu$; $\beta=320\mu$; $\gamma=320\mu$; $\varsigma=45\mu$.

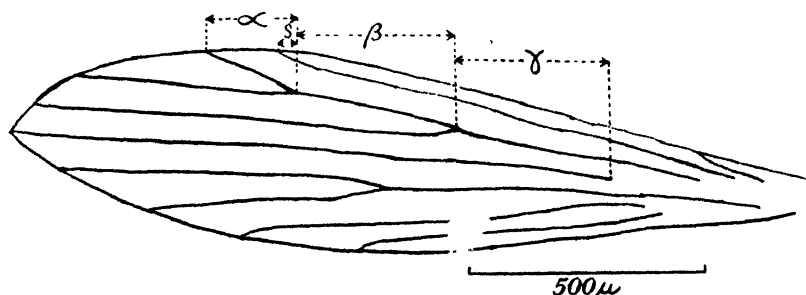


Fig. 6. Wing of undetermined species of *Phlebotomus*.

The spermathecae (fig. 5, *c*) are non-segmented, heavily chitinated, nearly spherical structures which open into rather wide ducts; the ducts unite to form a common duct. Length of spermatheca to breadth, 4:3.

The pharynx (fig. 2, *c*) is in some respects intermediate in type between that of *P. minutus* and *P. africanus*. As in the latter, the widest part posteriorly is twice as wide as the widest part anteriorly, but unlike the latter, the teeth are very strongly marked, even more so than in *P. minutus*. Posteriorly and laterally the borders of the pharynx do not terminate in two narrow processes and the posterior border of the pharynx is not so markedly indented as in *P. minutus*.

The buccal cavity (figs. 2, *c*; 4, *c*) contains a pigmented area posteriorly; this area is heart-shaped, with the apex pointing forwards. A toothed area is also present and the teeth are parallel and point backwards, as in *P. africanus*, but they are more prominent than those of the latter.

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COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology, between 1st October and 31st December, 1925, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance:—

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Dr. W. A. YOUNG :—2 *Glossina* ; from the Gold Coast.

GENERAL INDEX.

A

abdominalis, *Masicera*.

aberrans, *Tricholyga*.

aburiana, *Dimmockia*.

Acacia spp., lac insects on, in India, **38, 41**.

acaciæ, *Thrips*.

Achaea janata, migrations of, in India, **179**.

Achnanthes (*Micronetis*), associated with mosquito larvae in Ceylon, **226**.

Achrysocharis leptocerus, parasite of *Coelaenomenodera elaeidis* in the Gold Coast, **82**.

aconiti, *Phytomyza*.

Aconitum, *Phytomyza aconiti* mining in, in Britain, **95**.

acuminatus, *Mecostylus*.

Aedes (*Ochlerotatus*), effect of electric current on, **315**.

Aedes aegypti (see *A. argenteus*).

Aedes (*Stegomyia*) *albopictus*, factors in ecology of, **190**; oxygen requirements of, **196**; breeding-places of, **209**; oviposition of, **211, 213**.

Aedes argenteus, in the Dardanelles, **3**; experiments with trap breeding-places for, in Samoa, **151-153**.

Aedes caspius, in the Dardanelles, **3**.

Aedes detritus, in the Dardanelles, **3**.

Aedes (*Finlaya*) *greeni*, factors in ecology of, **190**.

Aedes (*Finlaya*) *gubernatoris*, factors in ecology of, **190**.

Aedes longirostris, factors in ecology of, **190**; breeding-places of, **209**.

Aedes (*Finlaya*) *macdougalli*, factors in ecology of, **190**; oxygen requirements of, **196, 197**.

Aedes pseudomediosciatus, factors in ecology of, **190**; breeding-places of, **209**.

Aedes (*Finlaya*) *pseudotaeniatatus*, factors in ecology of, **190**.

Aedes (*Stegomyia*) *sugens*, factors in ecology of, **190**; oxygen requirements of, **196, 197**.

Aedes (*Finlaya*) *trilineatus*, factors in ecology of, **190**; breeding-places of, **212**.

Aedes variegatus, experiments with trap breeding-places for, **151-153**.

aegypti, *Aedes* (see *A. argenteus*).

aegyptiacus, *Retithrips*.

Africa, South, new injurious weevils in, **67-71, 73**; thrips in, **135**.

africanus, *Closterocerus*; *Phlebotomus*.

Afrolachardina, raised to generic rank, **40**.

Agrotis ypsilon, migrations of, in India, **180**.

aikeni, *Anopheles*.

albida, *Tachardina*.

albimanus, *Anopheles*.

Albizzia lebbek, lac insects on, in India, **38**.

albizziae, *Laccifer*.

albopictus, *Aedes* (*Stegomyia*).

alecto, *Prophanurus*.

Aleurocanthus cutiperdus, in Ceylon, **274**.

Aleurocanthus niger, sp.n., on bamboo in Ceylon, **276**.

Aleurocanthus nigricans, sp.n., on bamboo in Ceylon, **277**.

Aleurocanthus obovatus, sp.n., on bamboo in Ceylon, **275**.

Aleurocanthus piperis, on *Piper* spp. in Ceylon, **275**.

Aleurocanthus spiniferus, on rose in Ceylon, **275**.

Aleurocanthus woglumi, food-plants of, in Ceylon, **275**.

Aleurocybotus setiferus, on *Imperata* in Ceylon, **274**.

Aleurodes hyperici, sp.n., on *Hypericum* in Ceylon, **274**.

Aleurodes sacchari (see *Neomaskellia bergi*).

Aleurodicus antidesmae, sp.n., on *Antidesma bumius* in Ceylon, **267**.

Aleurodicus holmesi, in Ceylon, **267**.

Aleurolobus flavus, on *Loranthus* in Ceylon, **279**.

Aleurolobus greeni, sp.n., in Ceylon, **280**.

Aleurolobus setigerus, on *Harpullia* in Ceylon, **279**.

Aleurolobus zeylanicus, sp.n., in Ceylon, **279**.

- Aleuroplatus ficus-gibbosae*, sp.n., on *Ficus gibbosa* in Ceylon, 271.
Aleuroplatus incisus, food-plants of, in Ceylon, 271.
Aleuroplatus (Orchamus) premnae, sp.n., on *Premna cordifolia* in Ceylon, 272.
Aleurotrachelus longispinus, sp.n., in Ceylon, 277.
 Algae, list of, associated with mosquito larvae in Ceylon, 218-226.
Allothra flavicornis, parasite of *Myzus cerasi* in Britain, 93.
Alternaria, associated with cotton boll rot in Queensland, 338.
altimus, *Stauropus*.
amabilis, *Eublemma*.
amaniensis, *Chionaspis (Inchoaspis)*.
Amathusia phidippus, Tachinid parasites of, in Malaya, 114, 121.
americanus, *Lasius niger*.
ampelophaga, *Theresia (Procris)*.
Amphigerontia (see *Psocus*).
amurensis, *Chrysops*.
Anatrachyntis falcata, parasite of lac insects in India, 38.
Andraca bipunctata, Tachinid parasite of, in Java, 121.
Andropogon, new Aleurodid on, in Ceylon, 278.
andropogonis, *Neomaskellia*.
annamensis, *Chelaeothrips*.
annulata, *Theobaldia*.
annulicaudis, *Brasema*.
Anona (see *Soursop*).
Anona squamosa, lac insects on, in India, 38.
Anopheles, effect of salt concentration on larvae of, 45-49; rearing of larvae of, 308.
Anopheles aiki, factors in ecology of, 190; oxygen requirements of, 196; breeding-places of, 201.
Anopheles albimanus, breeding in salt water, 45.
Anopheles barbirostris, factors in ecology of, 190; oxygen requirements of, 196; breeding-places of, 207.
Anopheles bifurcatus, in the Dardanelles, 4.
Anopheles chaudoyei (see *A. multicolor*).
Anopheles costalis, breeding in salt water, 45.
Anopheles crucians, breeding in salt water, 45; rearing of, under artificial conditions, 308.
Anopheles elutus, effect of salinity on oviposition of, 46.
Anopheles fuliginosus, factors in ecology of, 190; breeding-places of, 206.
Anopheles gigas, factors in ecology of, 190.
Anopheles jamesi, factors in ecology of, 190; oxygen requirements of, 196; breeding-places of, 206.
Anopheles karwari, factors in ecology of, 190; breeding-places of, 201.
Anopheles leucosphyrus, factors in ecology of, 190; breeding-places of, 201.
Anopheles listoni, factors in ecology of, 190; oxygen requirements of, 196; breeding-places of, 203; effect of excess of calcium carbonate on larva of, 233.
Anopheles maculatus, factors in ecology of, 190; oxygen requirements of, 196, 197; breeding-places of, 201; feeding habits of larva of, 227.
Anopheles maculipennis, in the Dardanelles, 4.
Anopheles multicolor, breeding in salt water, 45.
Anopheles quadrimaculatus, breeding in salt water, 45; rearing of, under artificial conditions, 308.
Anopheles rossi (?), breeding in salt water, 45.
Anopheles sergenti, effect of salinity on oviposition of, 46.
Anopheles sinensis, factors in ecology of, 190; oxygen requirements of, 196; breeding-places of, 207.
Anopheles superpictus, in the Dardanelles, 4; effect of salinity on oviposition of, 46.
Anopheles tessellatus, factors in ecology of, 190.
Anopheles vagus, factors in ecology of, 190; breeding in salt water, 196; oxygen requirements of, 196; breeding-places of, 207.
anopheloides, *Orthopodomys*.
Antestia lineatocollis, on coffee in Uganda, 347.
Anthonomus cyprinus, sp.n., on peach in Cyprus, 75.
Anthonomus ornatus, 75.
Anthonomus varians, 75.
Antidesma bunius, new Aleurodid on, in Ceylon, 268.
antidesmae, *Aleurodicus*.
Apanteles, parasite of *Helopeltis* in Java, 323.
aparines, *Myzus*.
Apelma, 356.
Aphidius cerasi, parasite of *Myzus cerasi* in Britain, 93.
aphidiivorus, *Lygocerus*.
Apocampta, 293, 303; not considered distinct from *Scaphia*, 299.
aranoides, *Rachionotomys*.
arbuti, *Euphyllura*.
arbuticola, *Psyllaephagus*.

Arbutus, Psyllid on, in California, **375**.
argentea, Haliday.
argenteus, Aëdes.
argentina, Tachardiella.
Armigeres aureolineatus, factors in ecology of, **190**.
Armigeres obturbans, factors in ecology of, **190**; breeding-places of, **198, 214**.
Artocarpus integrifolia, giant mealybug on, in India, **155**.
Artona caloxantha, Tachinid parasite of, in Malaya, **120**.
Aspergillus spp., associated with cotton boll rot in Queensland, **338**.
Aspidiotus hederæ, description of, **186**.
Aspidiotus nerii (see *A. hederæ*).
Astyphia, suggested use of name, **304**.
asymmetricum, *Platylecanium*.
ater, *Tabanus*.
Atractomorpha, **159, 160**.
atropivora, *Sturmia*.
Atylotus, status of, **305, 306**.
Aulacosternum nigrorubrum, on cotton in Queensland, **331**.
aurantii, *Chrysomphalus*.
aurata, *Scaptia*.
aurea, Haliday.
aureohirta, *Scaptia*.
aureolineatus, *Armigeres*.
austeni, *Culicoides*.
Australia, new Coccid from, **61**; nomenclature of Tabanidae of, **293-306**.
Australian Fluted Scale (see *Icerya purchasi*).
australis, *Demoplatus*; *Paracanthocera*; *Phenacaspis*; *Triphleps*.
Azeca, new Coccid associated with, in Brazil, **60**.
azteca, *Xiphosoma*.

B

Bacterium radicolica, **366**.
Bactrothrips longiventris, on cacao in Belgian Congo, **142**.
baeticus, *Polyommatus*.
bagnalli, *Haplithrips*.
bahri, *Culex*.
Bamboo, new Aleurodids on, in Ceylon, **275-277, 283**.
bambusae, *Laingiella*.
banksi, *Tectocoris* (see *T. lineola*).
barbifrons, *Protostrophus*.
barbistrotris, *Anopheles*.
Barium Chloride, against *Theresia ampelophaga* on vines, **397**.
Bark-beetles, distribution of, in pine trees in Sweden, **170-174**.
barraudi, *Culex*.
basifulva, *Erycia*.
Bauhinia, new Coccid on, in Uganda, **53**.
Bdellolarynx, considered distinct from *Haematobia*, **307**.
Bdellolarynx sanguinolentus, priority of, over *Haematobia nudinervis*, **307**.
Beans, new weevil on, in South Africa, **69**.
beckii, *Lepidosaphes*.
bedfordi, *Culicoides*.
Belgian Congo, thrips in, **125, 142**.
belia, *Macroglossa*.
belligera, *Haematopota*.
Bemisia emiliae, sp.n., on *Emilia sonchifolia* in Ceylon, **273**.
Bemisia leaki, **273**.
Bemisia religiosa, **273**.
bergi, *Ncomaskellia*.
bergrothi, *Helopeltis*.
Betel Pepper (see *Piper betle*).
biannulata, *Forcipomyia*.
bifarius, *Tabanus* (see *T. roussetii*).
bifasciata, *Copidapha*.
bifurcatus, *Anopheles*.
bimaculata, *Sturmia* (see *S. inconspicua*).
binoculatus, *Chrysops* (see *C. amurensis*).
bipunctalis, *Psara*.
bipunctata, *Andraca*.
bitaeniorhynchus, *Culex*.
Black Fly, Cherry (see *Myzus cerasi*).
Black Scale (in Palestine) (see *Chrysomphalus ficus*).
Bombyx mori, **229**.
Borassus, *Coelaenomenodera elaeidis* on, in the Gold Coast, **78**.
Brachystegia, *Glossina morsitans* associated with, in Tanganyika, **99-101**.
Bracon tachardiæ, parasite of lac insects in India, **38**.
Brasema annulicaudis, parasite of lac insects in India, **38**.
brassicæ, *Pieris*.
braueri, *Machatothrips*.
Brazil, new Coccid from, **59**; *Megastes grandalis* recorded from, **369, 372**.
brevicollis, *Oedemothrips*.
brevicornis, *Trioxys*.
brevipalpis, *Culex*.
brevirostris, *Scaptia*.
British Guiana, bionomics and control of sugar-cane moth borers in, **249-265**.
British Isles, bionomics of *Myzus cerasi* in, **85-94**.
buchwaldi, *Mecostylus*.
buffai, *Machatothrips braueri*.
bugnioni, *Microcerotermes*.
Bulbochaete, associated with mosquito larvae in Ceylon, **225, 226**.

Buplex, 294.

Butea frondosa, lac insects on, in India, 37, 38.

C

Cacao, thrips on, in Tropical Africa, 125, 142; *Helopeltis bergrothi* rare on, in Nigeria, 322.

Cacilius novoguineensis, in Fiji, 290. *caecutiens*, *Chrysops*.

Caesalpinia, thrips on, in Uganda, 126, 130.

Caesalpinia dasyrachis, new Coccid on, in Uganda, 57.

caesalpiniae, *Cyphococcus*.

cahurensis, *Haplothrips*.

calcutrans, *Stomoxys*.

Calcium Carbonate, effect of excess of, on mosquito larvae, 233.

California, parasites of Psyllids in, 375.

Caloptenus, fungus infesting, 365.

Calotermes dilatatus, characters of, in Ceylon, 383.

Calotermes greeni, characters of, in Ceylon, 382.

Calotermes militaris, characters of, in Ceylon, 380.

Calotermes militaris ab. *unidentatus*, n., in Ceylon, 381.

calyptroides, *Diaspis*.

Camels, *Lipoptena caprina* on, in Dardanelles, 23.

campestris, *Uranotaenia*.

canella, *Diatraea*.

capitatus, *Dialeurodes* (*Rhachisphora*).

Capparis spp., Aleurodids on, in Ceylon, 275.

caprina, *Lipoptena*.

Caprima conchylalis, Tachinid parasite of, in Ceylon, 116.

Capritermes hutsoni, sp.n., characters of, in Ceylon, 391.

Carcelia gnava, hosts of, in Ceylon, 116.

Carcelia modicella, hosts of, in Oriental region, 116.

Carphoborus chlodkovskyi, incidence of, in dying trees in Sweden, 170, 171.

caspius, *Aedes*.

Cassia multijuga, thrips on, in Ceylon, 139.

Castnia licus, on sugar-cane in British Guiana, 249.

Castor Oil Plant, thrips on, in Egypt, 125.

castrensis, *Culex*.

catoxantha, *Artona*.

cerasi, *Aphidius*; *Myzus*.

Ceratopogonines, from Tanganyika Territory, 355-357.

Ceromasia ferruginea, 119.

Ceromasia rutila (see *C. ferruginea*).

Ceroplastes floridensis, on *Citrus* in Palestine, 144.

Ceroplastodes ritchiei, sp.n., on *Anona* in Tanganyika Territory, 55.

Ceylon, Aleurodids of, 267-284; ecology of mosquito larvae in, 187-248; Tachinids from, 116, 121; notes on termites from, 379-392; new thrips in, 139.

ceylonicus, *Coptotermes*; *Eutermes*; *Odontotermes*; *Oedemolthrips*.

Chaelexorista javana, hosts of, in Oriental region, 117.

Chaetophora, association of, with mosquito larvae in Ceylon, 226.

Chaetosturmia, 115.

Chaff Scale (see *Parlatoria oleae*).

chalcographus, *Pityogenes*.

Chalcoscelis fumifera, Tachinid parasite of, in Malaya, 119.

chaudoyei, *Anopheles* (see *A. multicolor*).

Chelaeothrips annamensis, 140.

Chelaeothrips exunguis, 140.

Chelaeothrips idoliceps, sp.n., on *Ficus* in Fiji, 139.

Cherry, bionomics of *Myzus cerasi* on, in Britain, 85-94.

Cherry Black Fly (see *Myzus cerasi*).

chircensis, *Laccifer*.

Chionaspis amaniensis, 61.

Chionaspis hargreavesi, sp.n., in Uganda, 61.

Chlamydomonas, association of, with mosquito larvae in Ceylon, 226.

cholodkovskyi, *Carphoborus*.

chrysippus, *Danaus*.

Chrysomphalus auranti, on *Citrus* in Palestine, 144.

Chrysomphalus ficus, on *Citrus* in Palestine, 144.

Chrysops, 294; in Australia, 301.

Chrysops amurensis, characters of, 325.

Chrysops binocularis (see *C. amurensis*).

Chrysops caecutiens var. *meridionalis*, in the Dardanelles, 8.

Chrysops dissectus, characters of, 325.

Chrysops flavipes, in the Dardanelles, 8.

Chrysops (*Turanochrysops*, subgen. n.) *hyalipennis*, sp.n., in Transcaspiia, 326.

Chrysops (*Heterochrysops*) *italica*, in the Dardanelles, 8.

Chrysops loewi (see *C. makerovi*).

Chrysops makerovi, characters of, 326.

Chrysops maculiventris (see *C. punctifer*).

Chrysops mlokosiewiczzi (see *C. striatus*).

Chrysops nigripes, 326.

Chrysops oxianus, description of male, 326.

Chrysops punctifer, synonymy of, 326.

- Chrysops sakhalinensis*, a variety of *C. suavis*, **325**.
Chrysops striatus, **326**.
Chrysops suavis, characters of, **325**.
Chrysops testaceus, not a Tasmanian species, **301**.
cinerea, *Scaptia*.
 Cinnamon, Aleurodid on, in Ceylon, **271**.
citri, *Pseudococcus*.
citriperdus, *Aleurocanthus*.
 Citronella Grass (see *Cymbopogon*).
Citrus, Aleurodids on, in Java and Ceylon, **274**, **275**; fumigation of, in Palestine, **143-149**.
Cladophora, association of, with mosquito larvae in Ceylon, **226**.
Cladosporium herbarum, associated with cotton boll rot in Queensland, **338**.
Chidemia hirta, thrips on, in Trinidad, **132**.
Closterium spp., association of, with mosquito larvae in Ceylon, **226**.
Closterocerus africanus, parasite of *Coelaenomenodera claeidis* in the Gold Coast, **82**.
 Clover Root Mealybug (see *Trionymus trifolii*).
Clytho (see *Halidayia*).
Cnidocampa flavescens, Tachinid parasite of, in Japan, **117**.
 Coal Tar, against giant mealybug, **158**.
Coccobacillus acridiorum, a normal symbiont in locusts, **365**, **366**.
Coccoloba unifera, new Coccid on, in Trinidad, **52**.
Coccophagus tschirchii, parasite of lac insects in India, **38**.
Coccus lacca (see *Laccifer*).
 Coconut, Aleurodid on, in Ceylon, **275**; *Coelaenomenodera elaeidis* on, in the Gold Coast, **78**; new Coccids on, in New Britain and New Hebrides, **54**, **59**.
cocotis, *Platylecanium*.
Coelaenomenodera elaeidis (Oil Palm Leaf-miner), bionomics of, in the Gold Coast, **77-83**.
Coelomomyces stegomyiae, infesting mosquito larvae, **229**.
Coenoprosopon, **294**; *Demoplatus* doubtfully distinct from, **300**, **304**.
Coenoprosopon wainwrighti, possibly the female of *Demoplatus australis*, **300**.
 Coffee, new weevil on, in Kenya, **72**; bionomics and control of *Stephanoderes hampei* on, in Uganda, **347-354**; new thrips on, in Uganda, **182**.
 Coffee Berry-borer (see *Stephanoderes hampei*).
coffeicola, *Heterospilus*.
colmani, *Elasmus*.
Colias croceus fieldi, migrations of, in India, **181**.
coloratus, *Haplothrips cahirensis*.
communis, *Lakshadia*.
conchiferata, *Metatarchardia*.
conchylalis, *Caprinia*.
Conogethes (Dichocrocis) punctiferalis, on cotton in Queensland, **343**, **344**.
conspicua, *Corizoneura*.
 Copeognatha, notes on tropical species of, **285-290**.
Copidapha, **293**.
Copidapha bifasciata, a *nomen nudum*, **294**; identity of, **303**.
Coptotermes ceylonicus, characters of, **384**.
cordaluae, *Tachardiella*.
Cordyceps (Isaria) barberi, infesting *Diatraea* spp. in British Guiana, **259**, **261**.
Corethra plumicornis, heart beat of, **234**.
Corizoneura (see *Nuceria*).
Corizoneura conspicua, *Copidapha bifasciata* perhaps identical with, **294**.
cornuta, *Tachardiella*.
corsoni, *Forcipomyia*.
corticea, *Liparis*.
corvinoides, *Exorista*.
Cosmarium, association of, with mosquito larvae in Ceylon, **226**.
costalis, *Anopheles*.
costipunctata, *Hemithea*.
Cotterellia podagrica, parasite of *Coelaenomenodera claeidis* in the Gold Coast, **82**.
 Cotton, new weevils on, in South Africa, **67**, **68**, **70**; new Psocid on, in Fiji, **289**; new Coccid on, in Nigeria, **58**; bionomics of *Helopeltis* on, in Nigeria, **319-324**; bionomics of *Tectocoris lineola* on, in Queensland, **183**, **329-346**; *Sphenoptera gossypii* on, in Sudan, **313**.
 Cotton Boll Rot, insects and fungi associated with, in Queensland, **337-344**.
crawi, *Pseudococcus*.
Cremnops parvifasciatus (see *Microdus*).
cribrigerum, *Platylecanium*.
 Crimea, *Theresia ampelophaga* in vineyards in, **393-397**.
crinitus, *Operculaspis*.
croceus, *Colias*.
Crotalaria striata, thrips on, in Fiji, **126**.
crucians, *Anopheles*.
Cryphalus saltuarius, incidence of, in dying trees in Sweden, **173**.

- Cryptoplectria*, **294**; a synonym of *Demoplatus*, **300**.
Cryptostigma quinquepori, **60**.
Cryptostigma saundersi, sp.n., in Brazil, **59**.
Culex bahri, factors in ecology of, **190**; breeding-places of, **209**.
Culex barraudi, factors in ecology of, **190**; breeding-places of, **209**.
Culex bitaeniorhynchus, factors in ecology of, **190**; oxygen requirements of, **196**; breeding-places of, **205**; feeding habits of larva of, **227**; alkalinity of gut of, **229**.
Culex brevipalpis, factors in ecology of, **190**.
Culex castrensis, factors in ecology of, **190**; oxygen requirements of, **196**; breeding-places of, **205**.
Culex fatigans, factors in ecology of, **190**; oxygen requirements of, **196**, **197**; breeding-places of, **214**.
Culex (Culicomyia) fragilis, factors in ecology of, **190**; breeding-places of, **209**; toleration of, to saline ammonia, **199**.
Culex fuscocephalus, factors in ecology of, **190**; oxygen requirements of, **196**; breeding-places of, **209**.
Culex hortensis, in the Dardanelles, **3**.
Culex mimulus, factors in ecology of, **190**; oxygen requirements of, **196**; breeding-places of, **208**.
Culex minor, factors in ecology of, **190**; breeding-places of, **214**.
Culex minutissimus, factors in ecology of, **190**; oxygen requirements of, **196**; breeding-places of, **205**.
Culex (Culicomyia) pallidothorax, factors in ecology of, **190**; breeding-places of, **214**; toleration of, to saline ammonia, **199**.
Culex pipiens, in the Dardanelles, **4**.
Culex quasigelidus, habits of, in Mauritius, **316**.
Culex sitiens, factors in ecology of, **190**; breeding-places of, **208**.
Culex tritaeniorhynchus, factors in ecology of, **190**; oxygen requirements of, **196**; breeding-places of, **208**.
Culex uniformis, factors in ecology of, **190**; breeding-places of, **214**.
Culex vishnui, factors in ecology of, **190**; oxygen requirements of, **196**; breeding-places of, **209**.
Culex whitmorei, factors in ecology of, **190**; oxygen requirements of, **196**, **208**.
Culicomyia (see *Culex*).
Culicoides austeni, in Tanganyika, **357**.
Culicoides bedfordi, in Tanganyika, **357**.
Culicoides distinctipennis, in Tanganyika, **357**.
Culicoides guttularis, in the Dardanelles, **2**.
Culicoides nubeculosus, in the Dardanelles, **3**.
Culicoides pycnostictus, in Tanganyika, **357**.
Culicoides schultzei, in Tanganyika, **357**.
Culicoides similis, in Tanganyika, **357**.
cumingi, *Promecotheca*.
curvilineata, *Heptasmicra*.
Cyanotis, new Aleurodid on, in Ceylon, **283**.
cyanotis, *Zaphanera*.
Cydistomyia, **294**; doubtfully distinct from *Tabanus*, **301**.
Cymbopogon, new Aleurodid on, in Ceylon, **282**.
Cyperus, thrips on, in Fiji, **137**.
Cyphococcus, gen. n., **56**.
Cyphococcus caesalpiniae, sp.n., on *Caesalpinia dasyrachis* in Uganda, **56**.
cyprius, *Anthonomus*.
Cyprus, new weevil on peaches in, **75**.
- ## D
- dampfii*, *Frankliniella*.
Danais chrysippus, migrations of, in India, **179**.
Dardanelles, blood-sucking Diptera of, **1-23**.
Dasyapha, **304**.
Dasybasis, **293**; probably a synonym of *Tabanus (Therioptectes)*, **301**.
Dasychira grossa, Tachinid parasite of, in Java, **116**.
Dasyhelea flava, in Tanganyika, **357**.
Dasyhelea inconspicua, in Tanganyika, **357**.
Dasytystyia, supposed Australian species of, **306**.
decempunctata, *Dialeurodes (Dialeuropora)*.
decolor, *Selenothrips* (see *S. rubrocinctus*).
Delphinium, *Phytomyza aconiti* mining in, in Britain, **95**.
Demoplatus, **294**; characters of, **300**; compared with *Coenoprosopon*, **304**.
Demoplatus australis, *Coenoprosopon wainwrighti* possibly the female of, **300**.
Deodar, new Geometrid on, in India, **377**.
deodarae, *Ectropis*.
detritus, *Aedes*.
dewitzi, *Erencyrtus*.
diadema, *Stomatodexia*.

E

- Dialeurodes* (*Rhachisphora*) *capitatis*, sp.n., in Ceylon, **270**.
Dialeurodes (*Dialeuropora*) *decempunctata*, food-plants of, in Ceylon, **271**.
Dialeurodes (*Rabdostigma*) *loranthi*, sp.n., on *Loranthus* in Ceylon, **268**.
Dialeurodes (*Rabdostigma*) *radulinnealis*, on *Loranthus* in Ceylon, **268**.
Dialeurodes *radipunctata*, in Ceylon, **268**.
Dialeurodes (*Rhachisphora*) *rutherfordi*, on *Loranthus* in Ceylon, **269**.
Dialeurodes (*Rhachisphora*) *setulosa*, sp.n., in Ceylon, **270**.
Dialeurodes (*Rhachisphora*) *trilobitoides*, food-plants of, in Ceylon, **269**.
Dialeuropora (see *Dialeurodes*).
Diaspidæ, generic types of, **163-167**.
Diaspis calyptroides, considered a synonym of *D. echinocacti*, **164**.
Diaspis echinocacti, redescription of, **165**.
Diatmetus vittaticollis (see *Mecostylus*).
Diatoms, mosquito larvae feeding on, **220, 227, 229**.
Diatraea canella, bionomics and control of, on sugar-cane in British Guiana, **249-265**.
Diatraea lincolata, bionomics and control of, on sugar-cane in British Guiana, **249-265**.
Diatraea saccharalis, bionomics and control of, on sugar-cane in British Guiana, **249-265**.
Diatraea saccharalis oblitterellus, **250**.
diatraeae, *Euzenillioopsis*; *Microdus*.
Dichocrocis punctiferalis (see *Conogethes*).
dilatatus, *Calotermes*.
Dimmockia aburiana, parasite of *Coelaenomenodera elaeidis* in the Gold Coast, **82**.
Dinurothrips hookeri, on *Solanum* in Jamaica, **125**.
diplosia, *Lepidosaphes*.
dissectus, *Chrysops*.
distinctipennis, *Culicoides*.
distinctus, *Pseudotabanus*; *Silvius*.
divergens, *Krinothrips*.
Dixa zeylanica, factors in ecology of, **190**; oxygen requirements of, **196**; breeding-places of, **204**.
doddi, *Tabanus*.
Dog, *Lipoptena caprina* on, in Dardanelles, **23**.
Dolichos lablab, thrips on, in Tanganyika, **126, 130**.
Dysdercus sidae, on cotton in Queensland, **331, 337, 340, 344**.
Dysdercus supersticiosus, predacious on *Helopeltis* in Nigeria, **322**.
Earias huegeli, on cotton in Queensland, **340**.
ebrachiata, *Laccifer*.
echinocacti, *Diaspis*.
Echinocnemus oryzae, sp.n., on rice in India, **73**.
Ectatomma quadridens, predacious on *Diatraea* spp. in Br. Guiana, **259**.
Ectenopsis, **293, 305**; characters of, **300**.
Ectopsocus (*Micropsocus*) *myrmecophilus*, on *Jatropha curcas* in Fiji, **290**.
Ectopris deodarae, sp.n., on deodar in India, **377**.
edax, *Protostrophus*.
edentulus, *Tabanus*.
Egypt, thrips in, **125**.
elaedis, *Coelaenomenodera*.
Elaphromyia (see *Phibalomyia*).
Elasmopalpus lignosellus, on sugar-cane in Br. Guiana, **249**.
Elasmus colemani, parasite of lac insects in India, **39**.
Electric Current, effect of, on mosquito development, **315-317**.
elutus, *Anopheles*.
Emilia sonchifolia, new Aleurodid on, in Ceylon, **273**.
emiliae, *Bemisia*.
Ephedrus lacertosus, parasite of *Myzus cerasi* in Britain, **93**.
Epipsocus, key to Indo-Australian species of, **286**.
Epipsocus tahitiensis, sp.n., in Tahiti, **288**.
equina, *Hippobosca*.
Erannis marginaria, **377**.
Erencyrtus dewitzi, parasite of lac insects in India, **39**.
Erephopsis, characters distinguishing, from *Plinthina*, **295**; (see *Melpia*).
Erephopsis guttata, the type of the genus, **295**.
Eriocnusus hemipterus, parasite of *Tectocoris lineola* in Queensland, **345**.
eriogoni, *Pseudococcus*.
erithoniis, *Papilio*.
Erycia basifulva, sp.n., host of, in Malaya, **119**.
Erythrina, new Coccid on, in Uganda, **58**.
erythroga, *Pseudocryptera*.
escherichi, *Odontotermes*.
Eublemma amabilis, predacious on lac insects in India, **38**.
Eugenia operculata, Aleurodid on, in Ceylon, **269**.
Euglena, Anophelines feeding on, **219**.
Eunotia pectinalis, associated with mosquito larvae in Ceylon, **226**.

Eupelmus redini, parasite of *Tectocoris lineola* in Queensland, **345**.
Euphorus nigricarpus, parasite of *Helopeltis* in Nigeria, **323**.
Euphyllura arbuti, new parasite of, in California, **375**.
Euphyllura olivina, parasite of, in Mediterranean, **375**.
euphyllurae, *Psyllaephagus*.
Eutermes ceylonicus, characters of, in Ceylon, **388**.
Eutermes rubidus, characters of, in Ceylon, **389**.
Eutermes singaporiensis, **389**.
Euzenillioopsis diatraeae, parasite of *Diatraea saccharalis* in Cuba and Porto Rico, **261**; attempted introduction of, into Br. Guiana, **263, 265**.
exigua, *Lyperosia*.
Exorista corvinoides var. *rufella*, n., hosts of, in Oriental region, **119**.
Exorista laeviventris, host of, in Malaya, **118**.
exunguis, *Chelaeothrips*.

F

falcatella, *Anatrachyntis*.
Farinococcus formicarii, **54**.
Farinococcus simmondsi, sp.n., on coconut in New Britain, **54**.
Farinococcus simplicior, **54**.
fasciata, *Stegomyia* (see *Aedes argenteus*).
fasciatus, *Tabanus*.
fatigans, *Culex*.
 Federated Malay States, Tachinids from, **113-123**.
fenestrata, *Holcopsis*.
ferruginea, *Ceromasia*.
Ficalbia luzonensis, factors in ecology of, **190**; breeding-places of, **209**.
fici, *Laccifer*.
Ficus, thrips on, **135, 140, 141**.
Ficus bengalensis, lac insect on, in India, **38**.
Ficus benjamina, lac insect on, in India, **41**.
Ficus gibbosa, new Aleurodid on, in Ceylon, **272**.
Ficus mysorensis, lac insects on, in India, **38**.
Ficus religiosa, lac insect on, in India, **38**.
ficus, *Chrysomphalus*.
ficus-gibbosae, *Aleuroplatus*.
fieldi, *Colias croceus*.
 Fiji, *Aleurodicus holmesi* in, **267**; new Copeognatha from, **285-290**; thrips in, **126, 130, 137, 140**.
filamentosum, *Lecanium*.
 Fish-oil Resin Soap, against giant mealybug, **158**.

flava, *Dasyhelea*.
flavescens, *Cnidocampa*.
flavicornis, *Allothria*.
flavipennis, *Leskiopalpus*.
flavipes, *Chrysops*.
flavus, *Aleurolobus*.
 Florida Wax Scale (see *Ceroplastes floridensis*).
floridensis, *Ceroplastes*.
Forcipomyia biannulata, in Tanganyika, **357**.
Forcipomyia corsoni, sp.n., in Tanganyika, **355**.
Forcipomyia lepidota, in Tanganyika, **357**.
Forcipomyia murina, in Tanganyika, **357**.
formicarii, *Farinococcus* (*Tylococcus*).
Fragilaria, association of, with mosquito larvae in Ceylon, **226**.
fragilis, *Culex* (*Culiciomyia*).
Frankliniella dampfi, in Egypt and Uganda, **125**.
Frankliniella dampfi subsp. *interocellaris*, n., food-plants of, in Uganda, **126**.
fraseri, *Haematopota*; *Tabanus*.
Freycinetha banksi, new Coccid on, in New Zealand, **65**.
fuliginosus, *Anopheles*.
fullonica, *Ophideres*.
fulvithorax, *Pangonius*.
fumifera, *Chalcoscelis*.
funestus, *Protoctrophus* (*Strophosomus*).
 Fungi, associated with cotton boll rot in Queensland, **338**.
Fusarium moniliforme, associated with cotton boll rot in Queensland, **338, 344**.
fuscana, *Lutzia*.
fuscocephalus, *Culex*.

G

Galium aparine, food-plant of *Myzus cerasi* in Britain, **85-87, 92**.
Galium uliginosum, possibly a food-plant of *Myzus cerasi*, **91**.
Garcinia specta, Aleurodid on, in Ceylon, **271**.
 Giant Mealybug (see *Monophlebus stebbingi* var. *octocaudatus*).
gigas, *Anopheles*.
glaucopsis, *Tabanus*.
Glossina, relation of game to, **103**; effect of burning against, **104-107**.
Glossina morsitans, measures against in Tanganyika, **99-109**.
Glossina swynnertoni, measures against, in Tanganyika, **101-109**.
Glossinella schillingsi (see *Lyperosia*).
gnava, *Carcelia*.

Goats, *Lipoptena caprina* on, in Dardanelles, **23**.
 Gold Coast, bionomics of *Coelaenomeno-dera elaeidis* in, **77-83**.
Gonium, association of, with mosquito larvae in Ceylon, **226**.
gossypiella, *Platyedra*.
gossypii, *Sphenoptera*.
Gossypium spp., *Helopeltis* on, in Nigeria, **322**; (see Cotton).
grandalis, *Megastes*.
greeni, *Aedes* (Finlaya); *Aleurolobus*; *Calotermes*; *Laccifer*; *Microcero-termes*.
greenwoodi, *Pseudocaecilius*.
grenadensis, *Ipobracon*.
Grevillea, termites infesting, in Ceylon, **383, 387, 388**.
Grevillea robusta, new Coccid on, in Uganda, **54**.
grossa, *Dasychira*.
 Guava (see *Psidium guayava*).
Guazuma tomentosa, lac insects on, in India, **38, 41**.
gubernatoris, *Aedes* (Finlaya).
guttata, *Erephopsis*; *Scaptia*.
guttularis, *Culicoides*.
Gynaikothrips uzeli subsp. *hirsutus*, n , on *Ficus* in Uganda, **141**.
gyrovaga, *Hemimasicerca* (see *H. vicina*).

H

Hadronotus hirsutioculus, sp.n., para-site of *Tectocoris lineola* in Queensland, **183**.
Hadronotus nigricornis, in Queensland, **183**.
Haematobia, considered distinct from *Bdellolarynx*, **307**.
Haematobia nudinervis (see *Bdellolarynx sanguinolentus*).
Haematobia rufipes, identity of, **307**.
Haematopota belligera, sp.n., in the Dardanelles, **13**.
Haematopota fraseri, sp.n., in the Dardanelles, **9**.
Haematopota italica, **13**.
Haematopota latebricola, sp.n., in the Dardanelles, **11**.
Haematopota minuscularia, **11**.
Haematopota pluvialis, **13**.
haemorrhoidalis, *Heliothrips*.
Halidaya, key to species of, **121**.
Halidaya argentea, **121**.
Halidaya aurea, **121**.
Halidaya luteicornis, hosts of, in Malaya, **121**; redescription of, **122**.
Halimococcus nesioties, sp.n., on palm in Lord Howe Island, **51**.
hampei, *Stephanoderes*.
haplodon, *Machatothrips braueri*.
Haplothrips bagnalli, in Natal, **135**.
Haplothrips cahirensis, further description of, **135**; on mango in Uganda, **13**?
Haplothrips cahirensis var. *coloratus*, in Uganda, **137**.
Haplothrips soror, on *Cyperus* in Fiji, **137**.
harcyniae, *Pissodes*.
hargreavesi, *Chionaspis*; *Physothrips*; *Pseudococcus*.
Harpull'a, Aleurodid on, in Ceylon, **269**.
Harpullia pendula, Aleurodid on, in Ceylon, **279**.
haustellatus, *Pangonius*.
hederae, *Aspidiotus*.
Heliothis obsoleta, on cotton in Queensland, **340, 343**; new bug destroying eggs of, **361**.
Heliothrips haemorrhoidalis, food-plants of, **125**.
Helopeltis bergrothi, bionomics of, on cotton in Nigeria, **319-324**.
Helopeltis sanguineus, on cotton in Nigeria, **319, 321**.
Hemimasicerca gyrovaga (see *H. vicina*).
Hemimasicerca vicina, *Erycia basifulva* allied to, **119**.
hemiptera, *Stibasoma*.
hemipterus, *Erycdnus*; *Metamasius*.
Hemitheia costipunctata, Tachinid parasite of, in Malaya, **118**.
Heptasmicra curvilineata, parasite of *Diatraea* spp. in Br. Guiana, **259, 261**.
hesperidum, *Lecanium*.
Heterochrysops italica (see *Chrysops*).
Heterospilus coffeicola, parasite of *Stephanoderes hampei* in Uganda, **351**.
Hevea, termites infesting, in Ceylon, **384, 386**.
Hibiscus divaricatus, *Tectocoris lineola* on, in Queensland, **333**.
Hibiscus esculentus, *Sphenoptera gossypii* on, in Sudan, **313**.
Hippobosca equina, in the Dardanelles, **23**.
hirsutioculus, *Hadronotus*.
hirsutus, *Gynaikothrips uzeli*.
Holcocera pulvereae, parasite of lac insects in India, **38**.
Holcopsis, **294, 301**.
Holcopsis fenestrata, probably not an Australian species, **306**.
holmesii, *Aleurodicus*.
hookeri, *Dinuorhrips*.
Hoplandrothrips marshalli, sp.n., on coffee in Uganda, **131**.
horni, *Odontotermes*.
hortensis, *Culex*.
huegeli, *Earias*.

hutsoni, *Capritermes*; *Odontotermes horni*.
hyalipennis, *Chrysops* (*Turanochrysops*).
 Hydrocyanic Acid Gas, fumigation with, in Palestine, **144-148**.
 Hydrogen-ion Concentrations, toleration limits of mosquito larvae to, **190-195, 228**.
hyperici, *Aleurodes*.
Hypericum, new Aleurodid on, in Ceylon, **274**.
Hypotermes marshalli (see *Odontotermes*).

I

Icerya purchasi, on *Citrus* in Palestine, **144**.
idoliceps, *Chelaethrips*.
idonea, *Sturmia* (see *S. inconspicua*).
imberbis, *Sturmia* (see *S. inconspicua*).
immsi, *Tetrastichus*.
impar, *Sympiezotrachelus*.
Imperata arundinacea, Aleurodid on, in Ceylon, **274**.
inafectatus, *Sympiezotrachelus*.
Inchoaspis amaniensis (see *Chionaspis*).
incisus, *Aleuroplatus*.
inconspicua, *Sturmia*.
inconspicua, *Dasyhelea*.
 India, new Geometrid on deodars in, **377**; migrations of insects in, **179-181**; control of *Monophlebus stebbingi* var. *octocaudatus* in, **153-158**; Tachinids from, **114, 121**; new weevil on rice in, **74**.
indica, *Lakshadia* (see *Laccifer lacca*).
inferens, *Sesamia*.
inflaticornis, *Silvius*.
inopheron, *Lecanium*.
 Insecticide Dusts, simple form of distributor for, **175-176**.
insidiosus, *Triphleps*.
interocellaris, *Frankliniella dampfi*.
Iphiaulax medianus, *Ipobracon grenadensis* recorded as, in Br. Guiana, **259**.
Ipobracon grenadensis, parasite of *Diatraea* spp. in Br. Guiana, **259, 260**.
Ipobracon puberulus, parasite of *Diatraea* spp. in Br. Guiana, **259, 261**.
Ipobracon saccharalis, parasite of *Diatraea* spp. in Br. Guiana, **259**.
Ipomoea batatas (Sweet Potato), bio-nomics of *Megastes grandalis* on, in Trinidad, **369-372**; thrips on, in Uganda, **129, 130**.
Ipomoea hildebrandti, thrips on, in Uganda, **128, 130**.
Ips typographus, incidence of, in dying trees in Sweden, **172, 173**.
irritans, *Lyperosia*.
Isaria barberi (see *Cordyceps*).

Isaria stenobothri, infesting locusts, **365**.
italica, *Chrysops* (*Heterochrysops*); *Haematopota*.
Ixora parviflora, lac insect on, in India, **41**.

J

Jak (see *Artocarpus integrifolia*).
 Jamaica, thrips in, **125**.
jamesi, *Anopheles*.
janata, *Achaea*.
Jatropha curcas, Psocid on, in Fiji, **290**.
 Java, Aleurodids on *Citrus* in, **274, 275**; *Neomaskellia bergi* in, **278**; Tachinids from, **116, 117, 119, 120**.
javana, *Chaetexorista*.
javanicus, *Psocus*.
javanus, *Laccifer*.
johnstoni, *Lathromeris*.

K

kalabahensis, *Uranotaenia*.
karnyi, *Odontothrips*.
karwari, *Anopheles*.
 Keeling Islands, *Quilta mitrata* in, **160**.
 Kenya, new weevil on coffee in, **72**.
 Kerosene, against giant mealybug, **158**.
kerivillei, *Tabanus* (see *T. rousseli*).
kikuyensis, *Thrips*.
kingi, *Tabanus*.
 Krakatau, recovery of insect life on, **178**.
Krinothrips divergens, probably a synonym of *Bactrothrips longiventris*, **142**.
Kurrimia zeylanica, Aleurodid on, in Ceylon, **275**.
Kuwanina hilli, sp.n., on onion-weed in Queensland, **55**.

L

Lac Insects, supplement to a monograph of, **31-41**.
lacca, *Laccifer* (*Tachardia*).
Laccifer, key to species of, **33**.
Laccifer albizziae, **34**.
Laccifer chinensis, doubt as to identity of, **39**.
Laccifer ebrachiata, on *Ficus elastica* in India, **36**.
Laccifer fici, **36**.
Laccifer greeni, **35**.
Laccifer javanus, sp.n., in Java, **34**; details of anatomy of, **34**.
Laccifer lacca, synonymy of, **37**.
Laccifer meridionalis, **34**.

- Laccifer rangoonensis*, sp.n., in Burma, **35**.
Lacciferidae, supplement to a monograph of, **31-41**.
Lacciferinae, subfam. n., **32**.
lacertosus, *Ephedrus*.
laeviventris, *Exorista*.
Laingiella bambusae, gen. et sp.n., on bamboo in Ceylon, **283**.
Lakshadia communis, probably a synonym of *Laccifer lacca*, **38**.
Lakshadia indica (see *Laccifer lacca*).
Lakshadia mysorensis, probably a synonym of *Laccifer lacca*, **37, 38**.
Lakshadia nagoliensis, probably a synonym of *Laccifer lacca*, **37**.
Lakshadia sindica, probably a synonym of *Laccifer lacca*, **37**.
larreae, *Tachardiella*.
Lasius niger var. *americanus*, relations of, with *Trionymus trifolii*, **25**.
latebricola, *Haematopota*.
Lathromeris johnstoni, sp. n., parasite of *Sphenoptera gossypii* in Sudan, **309**.
Lathromeris scutellaris, characters of, **310-312**.
leaki, *Bemisia*.
Lecanium hesperidum, on *Citrus* in Palestine, **144**.
Lecanium inopheon, sp.n., on *Erythrina* in Uganda, **57**.
Lecanium filamentosum, **58**.
leleani, *Tabanus*.
Lepidium, a food-plant of *Myzus cerasi*, **91**.
Lepidosaphes beckii, on *Citrus* in Palestine, **144**.
Lepidosaphes diplasia, sp.n., in Tanganyika, **65**.
Lepidosaphes machili, **66**.
Lepidosaphes marshalli, sp.n., on *Freyinetia banksi*, in New Zealand, **64**.
Lepidosaphes unguolata, **65**.
leptocerus, *Achrysocharis*.
Leskiopalpus flavipennis, **259**.
leucosphyrus, *Anopheles*.
Lichenomima muscosa, in Fiji, **285**.
Lichenomima sumatrana, **285**.
licus, *Castnia*.
lignicola, *Psocus*.
lignosellus, *Elasmopalpus*.
Lilaea, **293**; not an Australian genus, **294, 304**; type of, **294**.
limbinervis, *Triclistia*.
limbithorax, *Osca*.
lineaticollis, *Anestia*.
lineola, *Tectocoris*.
lineolata, *Diatraea*.
Lioderma quadridentatum, predacious on *Diatraea* spp. in Br. Guiana, **259**.
Liothrips, key to African and Mediterranean species of, **183**.
Liothrips postocularis, sp.n., on *Ficus* in Uganda, **184**.
Liothrips urichi, on *Clidemia hirta* in Trinidad, **182**.
Liparis corticea, Tachinid parasite of, in Java, **119**.
Lipoptena caprina, in the Dardanelles, **23**.
Lissencyrtus somervilli, parasite of lac insects in India, **38**.
listoni, *Anopheles*.
litura, *Prodenia*.
lobata, *Tachardiella*.
Locusta migratoria, influence of temperature on development of, **363-367**.
loewi, *Chrysops* (see *C. makeroni*).
longiareolata, *Theobaldia*.
longirostris, *Aedes*; *Pangonius*.
longispinus, *Aleurotrachelus*.
longistylus, *Taeniothrips*.
longiventris, *Bactrothrips*.
loranthi, *Dialeurodes* (*Rabdostigma*).
Loranthus, *Aleurodids* on, in Ceylon, **268, 269, 279**.
Lord Howe Island, new Coccid from, **51**.
lugubris, *Protostraphus*.
lunatus, *Tabanus*.
luteicornis, *Halidayia*.
Lutzia fuscana, factors in ecology of, **190**; oxygen requirements of, **196**; predacious habits of, **198, 218**; toleration of, to saline ammonia, **199**.
luzonensis, *Ficalbia*.
lycii, *Tachardiella*.
Lygocerus aphidivorus, parasite of *Myzus cerasi* in Britain, **93**.
Lymantria monacha, defoliating pine trees in Sweden, **174**.
Lyngbya, association of, with mosquito larvae in Ceylon, **226**.
Lyperosia exigua, **307**.
Lyperosia irritans, in the Dardanelles, **22**.
Lyperosia minuta, **307**.
Lyperosia schillingsi, a good species, **307**.
Lyperosia titillans, in the Dardanelles, **22**.

M

- macdougalli*, *Aedes* (*Finlaya*).
Machatothrips braueri var. *buffai*, n., on cacao in West Africa, **142**.
Machatothrips braueri var. *haplodon*, n., in Uganda, **141**.
machili, *Lepidosaphes*.
Macroglossa belia, Tachinid parasite of, in Java, **116**.
macroporum, *Plinthina*.

- maculatus*, *Anopheles*.
maculipennis, *Anopheles*.
maculiventris, *Chrysops* (see *C. punctifer*); *Scaptia*.
 Madagascar, Tachinid from, **114**.
Mahasena, Tachinid parasite of, in Malaya, **121**.
 Maize, new weevil on, in South Africa, **71**.
makerovi, *Chrysops*.
 Malaria, incidence of, in Malaya and Ceylon, **244**.
 Mango, thrips on, **125, 130, 137**; giant mealybug on, in India, **155**.
marginaria, *Eranis*.
marginata, *Pangonia* (see *Pangonius haustellatus*).
marshalli, *Hoplandrothrips*; *Lepidosaphes*; *Odontotermes* (*Hypotermes*); *Physothrips* (see *P. ventralis*); *Pseudocaecilius*.
Masicera abdominalis, parasite of *Megastes grandalis* in Trinidad, **372**.
mathias, *Parnara*.
mauritica, *Spodoptera*.
 Mauritius, habits of *Culex quasigelidus* in, **316**.
 Mealy-bug, Clover Root (see *Trionymus trifolii*).
 Mealy-bug, Common (see *Pseudococcus citri*).
 Mealy-bug, Giant (see *Monophlebus stebbingi* var. *octocaudatus*).
Mecostylus acuminatus, sp. n., on coffee in Kenya, **71**.
Mecostylus buchwaldi, **72**.
Mecostylus (*Diatmetus*) *vittaticollis*, **72**.
medianus, *Iphiaulax*.
Megarhinus splendens, factors in ecology of, **190**; breeding-places of, **218**; predacious habits of, **218, 229**.
Megastes grandalis, anatomy and bionomics of, in Trinidad, **369-372**.
Melanconium sacchari, infesting sugarcane in British Guiana, **252**.
Melpia, not an Australian genus, **293**; *Erephopsis* a synonym of, **293**.
Melpia nigripennis, **293**.
Memecylon, Aleurodid on, in Ceylon, **268**.
mendax, *Selenothrips* (see *S. rubrocinctus*).
meridionalis, *Chrysops caecutiens*; *Lacifer*.
meruensis, *Physothrips*.
Mesomyia, **301, 304**.
Mesostenoides, parasite of *Diatraea* spp. in Br. Guiana, **259**.
Metamasius hemipterus, on sugar-cane in Br. Guiana, **252**.
Metatachardia conchiferata, **39**.
mexicana, *Tachardiella*.
Microcerotermes bugnioni, characters of, in Ceylon, **390**.
Microcerotermes greeni, characters of, in Ceylon, **391**.
Microdus diatraeae, parasite of *Diatraea* spp. in Br. Guiana, **259**.
Microdus parvifasciatus, parasite of *Diatraea* spp. in Br. Guiana, **259**.
micrographus, *Pityophthorus*.
Microneis (see *Achnanthes*).
Micropsocus myrmecophilus (see *Ectopsocus*).
 Migration, as a factor in pest-outbreaks, **177-181**.
migratoria, *Locusta*.
militaris, *Calotermes*.
mimulus, *Culex*.
minor, *Culex*; *Myelophilus*; *Odontotermes horni*.
minuscularia, *Haematopota*.
minuta, *Lyperosia*; *Tachardina*; *Tachydromia*.
minutissimus, *Culex*.
minutum, *Trichogramma*.
minutus, *Phlebotomus*.
 Mistletoe (see *Loranthus*).
mitrata, *Quilta*.
mlokosiewiczzi, *Chrysops* (see *C. striatus*).
modicella, *Carcelia*.
 Moluccas, *Uranotaenia papua* in, **44**.
monacha, *Lymantria*.
Monocrepidius, predacious on *Diatraea* spp. in Br. Guiana, **259**.
Monophlebus stebbingi var. *octocaudatus*, control of, in India, **155-158**.
mori, *Bombyx*.
morsitans, *Glossina*.
 Mosquito Larvae, algae associated with, in Ceylon, **218-226**; breeding-places of, **199-218**; oxygen requirements of, **196**; hydrogen-ion toleration limits of, **190-195, 228**; factors inimical to, **229-234**; rearing of, **308**; effect of electric current on development of, **315-317**.
 Mosquitos, trap breeding-places for, **151-153**; physical factors in ecology of, **187-248**; possibility of biological control of, **241-245**; classification of breeding-places of, **200-218**.
 Mulberry, Aleurodid on, in Ceylon, **271**.
multicolor, *Anopheles*.
murina, *Forcipomyia*.
muscosa, *Lichenomima*.
 Mussel Scale (see *Lepidosaphes beekii*).
mulator, *Protostrophus*.
Myelophilus minor, incidence of, in dying trees in Sweden, **170**.
Myelophilus piniperda, incidence of, in dying trees in Sweden, **170-174**.

Myopsocus, **285**.
myrmecophilus, *Ectopsocus* (*Micro-*
socus).
mysorensis, *Lakshadia*.
Myzus aparines, doubt as to identity
of, **85**.
Myzus cerasi, synonymy of, **85**; bio-
nomics of, in Britain, **85-94**.

N

nagoliensis, *Lakshadia*.
nasuta, *Prorops*.
neavei, *Physothrips*.
nebulosus, *Psocus*.
nemorals, *Tabanus*.
Neomaskellia andropogonis, sp.n., on
Andropogon in Ceylon, **278**.
Neomaskellia bergi, on grass in Ceylon;
278.
Neoscotia sorbillans (see *Tricholyga*).
Nephelium litchi, lac insects on, in
India, **38**.
nerii, *Aspidiotus* (see *A. hederae*).
nesiotis, *Halimococcus*.
New Britain, new Coccid from, **64**.
New Hebrides, new Coccid on coconut
in, **59**.
New Zealand, new Coccid from, **65**.
niger, *Aleurocanthus*; *Lasius*.
Nigeria, new Coccid on cotton in, **58**;
bionomics of *Helopeltis* on cotton in,
319-324; Psocid in, **285**; thrips on
cacao in, **142**.
nigricans, *Aleurocanthus*.
nigricarpus, *Euphorus*.
nigricornis, *Hadronotus*.
nigripennis, *Melpia*.
nigripes, *Chrysops*; *Pleurotropis*.
nigrorubrum, *Aulacosternum*.
nloticus, *Tabanus fasciatus*.
nitens, *Selora*.
Notolophus posticus, Tachinid parasite
of, in Malaya, **121**.
novoguineensis, *Caecilius*.
nubeculosus, *Culicoides*.
Nuceria, *Corizoneura* a synonym of,
293; type of the genus, **293**.
nudinervis, *Haematobia* (see *Bdello-*
larynx sanguinolentus).
Nun Moth (see *Lymantria monacha*).

O

obliquecinctus, *Protoctrophus*.
obliterellus, *Diatraea saccharalis*.
obovalis, *Aleurocanthus*.
obscuriceps, *Odontotermes*.
obsoleta, *Heliothis*.
obturbans, *Armigeres*.
Ochlerotatus (see *Aedes*).

Ochrops rusticus (see *Tabanus*).
octocaudatus, *Monophlebus stebbingi*.
Odontotermes ceylonicus, characters of,
in Ceylon, **386**.
Odontotermes escherichi, characters of,
in Ceylon, **386**.
Odontotermes horni, characters of, in
Ceylon, **384**.
Odontotermes horni var. *hutchinsoni*, n., in
Ceylon, **384**.
Odontotermes horni var. *minor*, n., in
Ceylon, **385**.
Odontotermes marshalli, sp.n., in Ceylon,
387.
Odontotermes obscuriceps, **387**.
Odontotermes redemanni, characters of,
in Ceylon, **386**.
Odontotermes sumatrensis, **387**.
Odontotermes xenotermis, **387**.
Odontothrips karnyi, **126**.
oecleus, *Telenomus*.
Oedemothrips brevicollis, **139**.
Oedemothrips ceylonicus, sp.n., on *Cas-*
sia multijuga in Ceylon, **137**.
Oil Emulsion, against giant mealybug,
158.
Oil Palms, *Coelaenomenodera elaeidis*
on, in the Gold Coast, **77-83**.
olrac, *Parlatoria*.
Olive, *Euphyllura olivina* on, **375**.
olivina, *Euphyllura*.
Ommia, **293**.
Ommia prisca, doubt as to identity of,
301, 305.
opacicolis, *Promecotheca*.
Operculaspis, gen.n., **62**.
Operculaspis crinitus, sp.n., in Tan-
ganyika, **63**.
Ophideres jullonica, Tachinid parasite
of, in Java, **116**.
Ophrys aranifera, a foodplant of
Myzus cerasi, **91**.
oppugnator, *Tabanus*.
Orchamus premnae (see *Aleuroplatus*).
ornatus, *Anthonomus*.
Orthopodomys anopheloides, factors in
ecology of, **190**.
oryzae, *Echinocnemus*; *Quilla*.
Osca, **294**; characters distinguishing
from *Scaptia*, **294, 295**.
Osca limbithorax, head of, **295**.
Ostodes zeylanica, Aleurodid on, in
Ceylon, **271**.
oxianus, *Chrysops*.
Oxygen, requirements of, by mosquito
larvae, **196**.

P

Pachycrepis tectacoris, parasite of *Tec-*
tocoris lineola in Queensland, **345**.
pachyphyllae, *Psyllaephagus*.

- Palestine, effect of salt concentration on Anopheline larvae in, **45-49**; fumigation of *Citrus* trees in, **143-149**; list of Coccids infesting *Citrus* in, **144**; *Phlebotomus minutus* and allied species in, **399-405**.
- Palmmecomomyia*, **294**; characters of, **300**.
- Palmmecomomyia walkeri*, head of, **300**.
- palldothorax*, *Culex* (*Culicomyia*).
- Pangonia* (see *Pangonius*).
- Pangonia marginata* (see *Pangonius haustellatus*).
- Pangoniinae list and synonymy of Australian genera of, **302**.
- Pangonius fulvithorax*, the type of *Melpia*, **293**.
- Pangonius haustellatus*, in the Dardanelles, **5**.
- Pangonius haustellatus* var. *tenuipalpis*, **6**.
- Pangonius longirostris*, the type of *Nuceria*, **293**.
- Pangonius pyritosus*, in the Dardanelles, **6**.
- Panicum barbinode*, food-plant of sugarcane moth borers in Br. Guiana, **250**.
- papatasi*, *Phlebotomus*.
- Papiho erithonius*, migrations of, in India, **179**.
- papua*, *Uranotaenia*.
- Paracanthocera*, **294**.
- Paracanthocera australis*, **301**.
- parachrysops*, *Sturmia*.
- paradoxa*, *Surcoufia*.
- Paraleyrodes*, **283**.
- Parasilvius*, **294**; characters of, **300**.
- Paris Green, against *Theresia ampelophaga* on vines, **397**.
- Parlatoria oleae*, on *Citrus* in Palestine, **144**.
- Parnara mathias*, Tachinid parasite of, in Malaya, **121**.
- parvifasciatus*, *Microdus* (*Cremnops*).
- Paspalum virgatum*, food-plant of sugarcane moth borers in Br. Guiana, **250**.
- Peach, new weevil on, in Cyprus, **75**; giant mealybug on, in India, **155**.
- Pelecorrhynchus*, **293, 303**.
- Pepper, Betel (see *Piper betle*).
- Peridermium piri*, incidence of, in dying trees in Sweden, **170, 172**.
- Perisopterus*, parasite of lac insects in India, **41**.
- perniciosus*, *Phlebotomus*.
- perplexus*, *Plesiothrips*.
- pfeifferi*, *Xanthogramma*.
- Phenacaspis australis*, sp.n., in Australia, **61**.
- Phenacoccus trinidadensis*, sp.n., on *Coccoloba uvifera* in Trinidad, **52**.
- Phibalomyia*, **294**; characters of, **300**.
- phidippus*, *Amathusia*.
- Phlebotomus*, characters of pharynx and buccal cavity used for classification of, **400-403**.
- Phlebotomus africanus*, not a variety of *P. minutus*, **399**; characters of, **400, 402**; in the Dardanelles, **5**.
- Phlebotomus minutus*, characters of, **399, 401, 403**.
- Phlebotomus papatasi*, in the Dardanelles, **5**; buccal characters of, **400**.
- Phlebotomus perniciosus*, buccal characters of, **400**.
- Phormidium tenue*, association of, with mosquito larvae in Ceylon, **226**.
- Photinea serrulata*, a food-plant of *Myzus cerasi*, **91**.
- Phthorophloeus spinulosus*, incidence of, in dying trees in Sweden, **173**.
- Physothrips hargreavesi*, sp.n., on *Tephrosia* in Uganda, **127**.
- Physothrips marshalli* (see *P. ventralis*).
- Physothrips meruensis*, **126**.
- Physothrips neavei*, sp.n., on *Ipomoea* in Uganda, **129**.
- Physothrips sjöstedti*, food-plants of, in East Africa, **126**.
- Physothrips ventralis*, food-plants of, in Uganda, **128**.
- Phytomyza aconiti*, *Tachydromia minuta* predacious on, in Britain, **95**.
- Pieris brassicae*, migrations of, in India, **179**.
- Pines, distribution of bark-beetles in, in Sweden, **170-174**.
- pini*, *Pissodes*.
- piniperda*, *Myelophilus*.
- piniphilus*, *Pissodes*.
- Piper betle*, Aleurodid on, in Ceylon, **275**.
- piperis*, *Aleurocanthus*.
- piptiens*, *Culex*.
- Pissodes harcyniae*, incidence of, in dying trees in Sweden, **172, 173**.
- Pissodes pini*, incidence of, in dying trees in Sweden, **170**.
- Pissodes piniphilus*, incidence of, in dying trees in Sweden, **170**.
- Pistia stratiotes*, effect of, on mosquito larvae, **237**; Tabanid larva associated with, **359**.
- Pithecolobium* spp., lac insects on, in India, **38**.
- Ptyogenes chalcographus*, incidence of, in dying trees in Sweden, **172, 173**.
- Pityophthorus micrographus*, incidence of, in dying trees in Sweden, **172, 173**.
- Pityophthorus trågårdhi*, incidence of, in dying trees in Sweden, **172, 173**.
- plagiata*, *Tiracola*.
- planatus*, *Protothrophus*.
- Plantain, thrips on, in Uganda, **130**.

- Platyedra gossypiella*, on cotton in Queensland, **340, 344**.
Platylecanium asymmetricum, **59**.
Platylecanium cocotis, sp.n., on coconut in New Hebrides, **59**.
Platylecanium cribrigerum, anal plate of, **59**.
Plesiothrips perplexus, on sugar-cane in Fiji, **130**.
Pleurotropis nigripes, hyperparasite of *Coelaenomenodera elaeidis* in the Gold Coast, **82**.
Plinthina, **293**; characters distinguishing from *Erephopsis*, **295**; considered a subgenus of *Scaphia*, **229**; suggested use of name, **304**.
Plinthina macroporum, the type of the genus, **295**.
 Plum, giant mealybug on, in India, **155**.
plumicornis, *Corethra*.
pluvialis, *Haematopota*.
podagrica, *Cotterellia*.
Podomyia setosa, host of, in Malaya, **120**.
Podotachina sorbillans (see *Tricholyga*)
poligraphus, *Polygraphus*.
polychloros, *Vanessa*.
Polygraphus poligraphus, incidence of, in dying trees in Sweden, **172, 173**.
Polyommatus baeticus, migrations of, in India, **179**.
 Porto Rico, parasite of *Diatraea* introduced into Br. Guiana from, **264**.
posticus, *Notolophus*.
postocularis, *Liothrips*.
Premna cordifolia, new Aleurodid on, in Ceylon, **273**.
premnac, *Aleuroplatus* (*Orchamus*).
prisca, *Ommia*.
Procris ampelophaga (see *Theresia*).
Prodenia litura, Tachinid parasite of, in Malaya, **120**.
Promecotheca cumingi, **77**.
Promecotheca opacicollis, **77**.
Prophanurus alecto, parasite of *Diatraea* spp. in Br. Guiana, **259**.
Prorops nasuta, parasite of *Stephanoderes hampei* in Uganda, **350**.
Protostrophus barbifrons, **68**.
Protostrophus edax, sp.n., on cotton in South Africa, **67**.
Protostrophus (*Strophosomus*) *junestus*, on cotton in South Africa, **70**.
Protostrophus lugubris, sp.n., on cotton in South Africa, **68**.
Protostrophus mutator, sp.n., on beans in South Africa, **68**.
Protostrophus obliquecinctus, **69**.
Protostrophus planatus, **71**.
Protostrophus rotundus, sp.n., on maize in South Africa, **70**.
Protostrophus vorax, sp.n., on cotton in South Africa, **69**.
Prunus spp., food-plants of *Myzus cerasi*, **91**.
Psara bipunctalis, Tachinid parasite of, in Malaya, **115**.
Pseudocacculus greenwoodi, sp.n., in Fiji, **290**.
Pseudocacculus marshalli, sp.n., on cotton in Fiji, **288**.
Pseudocacculus solocipennis, **288**.
Pseudocacculus vetchi, sp.n., in Fiji, **289**.
Pseudococcus citri, **25, 28, 29**; on *Citrus* in Palestine, **144**.
Pseudococcus crawi, **53**.
Pseudococcus eriogoni, **54**.
Pseudococcus hargreavesi, sp.n., on *Bauhinia* in Uganda, **52**.
Pseudococcus ugandae, sp.n., on *Grevillea robusta* in Uganda, **53**.
Pseudococcus wistariae, **53**.
Pseudocryptera erythroga, sp.n., in Malaya, **122**.
pseudomediofasciatus, *Aedes*.
Pseudopangonia, **294, 305**; characters of, **300**.
pseudoscutellaris, *Stegomyia* (see *Aedes variegatus*).
Pseudotabanus, **294**; doubtfully distinct from *Sileus*, **301**.
Pseudotabanus distinctus, **301**.
pseudotaenariatus, *Aedes* (*Finlavi*).
Psidium, Aleurodid on, in Fiji, **267**.
Psidium guayava (*Guava*), *Helopeltis* on, in Nigeria, **322**.
Psocus javanicus, **286**.
Psocus lignicola, **286**.
Psocus nebulosus, in Nigeria, **285**.
Psocus nebulosus var. *usambaranus*, **285**.
Psocus similis, **286**.
Psocus (*Amphigerontia*) *utiensis*, sp.n., in Fiji, **285**.
Psyllaephagus arbuticola, sp.n., parasite of Psyllids in California, **373**.
Psyllaephagus euphyllurae, parasite of *Euphyllura olivina* in Italy, **375**.
Psyllaephagus pachypsyllae, **373**.
Psyllaephagus solus, further description of, **375**.
 Psyllids, notes on parasites of, **373-375**.
Ptychomyia remota, parasite of *Artona catoxantha* in Malaya, **120**.
Ptychomyia selecta, **120**.
puberulus, *Ipobracon*.
pulchripes, *Simulium*.
pulverea, *Holcocera*.
puncticollis, *Triphleps*.
punctifer, *Chrysops*.
punctiferalis, *Conogethes* (*Dichocrocis*).

purchasi, *Icerya*.
pycnostictus, *Culicoides*.
pyrilosus, *Pangonius*.

Q

quadridens, *Ectatomma*.
quadridentatum, *Lioderma*.
quadrimaculatus, *Anopheles*.
quadripustulata, *Winthemia*.
quasigelidus, *Culex*.
quatunotatus, *Tabanus*.
 Queensland, new Coccid from, 55;
 new bug destroying eggs of *Heliothis*
obsoleta in, 361; bionomics of
Tectocoris lineola in, 183, 329-346.
Quilta mitrata, *Q. oryzae* compared
 with, 160.
Quilta oryzae, sp.n., on rice in Siam,
 159.
quinquepori, *Cryptostigma*.

R

Rabdostigma (see *Dialeurodes*).
Rachionotomyia aranoides, factors in
 ecology of, 190; breeding-places of,
 214.
radiilincalis, *Dialeurodes* (*Rabdostigma*).
radiopunctata, *Dialeurodes*.
rangoonensis, *Iaccifer*.
 Red Scale (see *Chrysomphalus*
aurantii).
redemanni, *Odontotermes*.
redini, *Eupelmus*.
regis-georgei, *Scaptia*.
religiosa, *Bemisia*.
remota, *Ptychomyia*.
renardi, *Summus*.
Retithrips argyptuacus, food-plants of,
 in Egypt, 125.
Rhachisphora (see *Dialeurodes*).
Rhizopus arrhizus, associated with
 cotton boll rot in Queensland, 338.
 Rice, new weevil on, in India, 74;
 new grasshopper, on in Siam, 159-161.
 Rice-fields, development of mosquito
 larvae in, 238-241.
 Rice-water, experiments with mos-
 quito larvae and, 215-217.
richiardi, *Taeniorhynchus*.
richiei, *Ceroplastodes*.
 Rose, thrips on, in Africa, 125;
 Aleurodid on, in Ceylon, 275.
rossi, *Anopheles*.
rotundus, *Protoctrophus*.
rousseleti, *Tabanus*.
rubidus, *Eutermes*.
rubrocinctus, *Selenothrips*.

rufella, *Exorista corvinoides*.
ruficornis, *Scaptia*.
rufipes, *Haematobia*.
rugosus, *Tetraleurodes*.
rusticus, *Tabanus* (*Ochrops*).
rutherfordi, *Dialeurodes* (*Rhachisphora*).
rutila, *Ceromasia* (see *C. ferruginea*).

S

saccharalis, *Diatraea*; *Ipobracon*.
sacchari, *Aleurodes* (see *Neomaskellia*
bergi).
Sackenimyia, 293.
sakhalinensis, *Chrysops*.
Salacia reticulata, Aleurodid on, in
 Ceylon, 275.
 Saline Ammonia, toleration limits of
 mosquito larvae to, 198.
 Salt, effect of, on Anopheline larvae in
 Palestine, 45-49.
saltuarius, *Cryphalus*.
 Samoa, *Neomaskellia bergi* in, 278.
 San Thomé, *Neomaskellia bergi* in, 278.
sanguineus, *Helopeltis*.
Saprolegnia, infesting mosquito larvae,
 229.
Sarcophaga sternodonta, parasite of
Megastes grandis in Trinidad, 372.
saundersi, *Cryptostigma*.
Scaptia, 293; characters distinguishing
 , from *Oscia*, 294, 295; characters of
 species of, 295-298; synonymy of
 species of, 304.
Scaptia aurata, head of, 295.
Scaptia aureohirta, head of, 296.
Scaptia brevisrostris, head of, 296.
Scaptia cinerea, head of, 298.
Scaptia guttata, head of, 295.
Scaptia maculiventris, head of, 296.
Scaptia regis-georgei, head of, 297.
Scaptia ruficornis, head of, 298.
Scaptia subcana, head of, 298.
Scaptia vicina, head of, 297.
Scaptia violacea, head of, 298.
Scarites, predacious on *Diatraea* spp.
 in Br. Guiana, 259.
schillingei, *Lyperostia* (*Glossinella*).
Schleichera trijuga, lac insects on, in
 India, 37.
schönbaueri, *Simulium*.
schultzei, *Culicoides*.
scutellaris, *Lathromeris*.
selecta, *Ptychomyia*.
Selenothrips decolor (see *S. rubrocinctus*).
Selenothrips mendax (see *S. rubrocinctus*).
Selenothrips rubrocinctus, food-plants
 of, 125.
semiberbis, *Winthemia*.
semilunaris, *Tetraleurodes*.
sergenti, *Anopheles*.

- sericariae*, *Sturmia*.
Sericophoromyia, **115**.
Sesamia inferens, Tachinid parasite of, in Malaya, **115**.
Sesbania, thrips on, in Uganda, **126**.
setiferus, *Aleurocybotus*.
setigerus, *Aleurolobus*.
Setora nitens, Tachinid parasite of, in Malaya, **117**.
setosa, *Podomyia*.
setulosa, *Dialeurodes* (*Rhachisphora*).
 Seychelles, Tachinid from, **114**.
sharppei, *Tabanus*.
Shorea talura, lac insects, on in India, **38**.
 Siam, new grasshopper on rice in, **159-161**.
sidae, *Dysdercus*.
silvestrii, *Tachardina*.
Silvius, **294**; *Pseudotabanus* doubtfully distinct from, **301**; species of, **304**.
Silvius distinctus, **301**.
Silvius inflatocornis, sp.n., in the Dardanelles, **6**.
similaris, *Psocus*.
similis, *Culicoides*.
simmondsi, *Farinococcus*.
simplicior, *Farinococcus* (*Tylococcus*).
Simulium pulchripes, sp.n., in the Dardanelles, **4**.
Simulium schonbaueri, **5**.
sindica, *Lakshadia*.
sinensis, *Anopheles*.
singaporiensis, *Eutermes*.
singularis, *Trichista*.
sitens, *Culex*.
 Soft Scale (see *Lecanium hesperidum*).
Solanum, thrips on, in Jamaica, **125**.
solocipennis, *Pseudocaecilius*.
solus, *Psyllaephagus*.
somervillei, *Lissencyrtus*.
sorbillans, *Tricholyga* (*Neoscotia*, *Podotachina*).
Sorghum, Aleurodid on, in India, **278**.
soror, *Haplothrips*.
Soursop (*Anona*), new Coccid on, in Tanganyika, **56**.
spectabilis, *Tabanus*.
Sphenoptera gossypii, new parasite of, in Sudan, **309-313**.
spiniferus, *Aleurocanthus*.
spinulosus, *Phthorophloeus*.
Spirogyra, relation of, to mosquito larvae, **206, 222, 226, 227, 231, 236, 238, 240, 245, 308**.
splendens, *Megarhinus*.
Spodoptera mauritia, Tachinid parasite of, in India, **114**.
Spondias lutea (Hogplum), *Helopeltis* on, in Nigeria, **322**.
Stauropus alternus, Tachinid parasite of, in Ceylon, **116**.
stebbingi, *Monophlebus*.
Stegomyia fasciata (see *Aedes argenteus*).
Stegomyia pseudoscutellaris (see *Aedes variegatus*).
Stenobothrus, fungus infesting, **365**.
Stenotabanus, key distinguishing, from *Tabanus*, **305**.
Stephanodreps hampei, bionomics and control of, in Uganda, **347-354**.
sternodonta, *Sarcophaga*.
Stibasoma, **294**.
Stibasoma hemiptera, probably not an Australian species, **301**.
Stomalodexia, parasite of *Diatraea* spp. in Br. Guiana, **259**.
Stomalodexia diadema, **259**.
Stomoxys calcitrans, in the Dardanelles, **22**.
Straba, key distinguishing, from *Tabanus*, **305**.
striatus, *Chrysops*.
Sturmia atropivora, in Federated Malay States, **114**.
Sturmia bimaculata (see *S. inconspicua*).
Sturmia idonea (see *S. inconspicua*).
Sturmia imberbis (see *S. inconspicua*).
Sturmia inconspicua, hosts of, in Federated Malay States, **114**.
Sturmia parachrysops, sp.n., in Federated Malay States, **114**.
Sturmia sericariae, in Federated Malay States, **114**.
suavis, *Chrysops*.
subcana, *Scaptia*.
 Sudan, new parasite of *Sphenoptera gossypii* in, **309-313**; bionomics of *Tabanus fasciatus niloticus* in, **359**.
 Sugar-cane, new weevil on, in S. Africa, **72**; thrips on, in Fiji, **130**; bionomics and control of moth borers in, in Br. Guiana, **249-265**; Aleurodid on, in India, **278**.
sugens, *Aedes* (*Stegomyia*).
sumatrana, *Lichenomima*.
sumatrensis, *Odontotermes*.
Sumnius renardi, predacious on mealybug in India, **158**.
 Sunda Islands, new mosquito from, **43**.
superpictus, *Anopheles*.
superstitiosus, *Dysdercus*.
Surcoufia paradoxa, **8**.
 Sweden, entomological analyses of trees in, **169-174**.
 Sweet Potato (see *Ipomoea batatas*).
 Sweet Potato Pyralid (see *Megastes grandalis*).
swynnertonii, *Glossina*.
Sympiezotrachelus impar, sp.n., on sugar-cane in South Africa, **78**.

Sympiezotrachelus inafectatus, 73.
Synedra vitrea, association of, with mosquito larvae in Ceylon, 226.
Sziladya, 306.

T

- Tabanidae, nomenclature of Australian species of, 293-306.
Tabanus, 294; key distinguishing *Stenotabanus* and *Straba* from, 305.
Tabanus ater, in the Dardanelles, 15.
Tabanus bifarius (see *T. roussellii*).
Tabanus doddi, 301.
Tabanus edentulus, systematic position of, 304.
Tabanus fasciatus niloticus, bionomics of larva of, in Sudan, 359.
Tabanus fraseri, sp.n., in the Dardanelles, 17.
Tabanus glaucopsis, 20.
Tabanus kervillei (see *T. roussellii*).
Tabanus kingi, habitat of larva of, in Sudan, 359.
Tabanus lcleani, in the Dardanelles, 17.
Tabanus lunatus, in the Dardanelles, 17.
Tabanus nemoralis, 22.
Tabanus oppugnator, sp.n., in the Dardanelles, 20.
Tabanus quatuornotatus, 22.
Tabanus roussellii, in the Dardanelles, 16.
Tabanus (Ochrops) rusticus, 16; *T. roussellii* not a synonym of, 16.
Tabanus sharpei, 301.
Tabanus spectabilis, in the Dardanelles, 15.
Tabanus umbrinus, in the Dardanelles, 17.
Tachardia, a synonym of *Laccifer*, 32.
tachardiæ, *Bracon*.
Tachardiella argentina, a good species, 40.
Tachardiella cordaliae, in Argentina, 40.
Tachardiella cornuta, 39.
Tachardiella larreae, 39.
Tachardiella lycii, 40.
Tachardiella mexicana, 40.
Tachardiella texana (see *T. mexicana*).
Tachardiinae (see *Lacciferidae*).
Tachardina albida, 41.
Tachardina lobata, 41.
Tachardina minuta, 41.
Tachardina silvestrii, doubt as to identity of, 41.
Tachardina ternata, on *Acacia sundra* in India, 41.
Tachinidae, from Federated Malay States, 113-123.
Tachydromia minuta, predacious on *Phytomyza aconiti* in Britain, 95-97.
Taeniorhynchus richiardi, in the Dardanelles, 3.
Taeniothrips longistylus, in Fiji, 126.
tagalicus, *Tectocoris lineola*.
Tahiti, new *Epipsocus* from, 288.
tahitiensis, *Epipsocus*.
Tanganyika Territory, *Ceratopogonines* from, 355-357; new *Coccids* from, 56, 64, 66; tsetse-fly problem in, 99-109; thrips in, 126, 130.
Tea, termites infesting, in Ceylon, 381-387, 389, 392.
tectacorsi, *Pachycrepis*.
Tectocoris banksi (see *T. lineola*).
Tectocoris lineola, bionomics of, on cotton in Queensland, 329-346; new parasite of, 183.
Tectocoris lineola var. *tagalicus*, 330 note.
Telenomus, 259.
Telenomus occlusus, parasite of *Tectocoris lineola* in Queensland, 345.
tenuipalpis, *Pangonius haustellatus*.
Tephrosia, thrips on, in Uganda, 126, 128.
Ternutes, notes on, from Ceylon, 379-392.
ternata, *Tachardina*.
tessellatus, *Anopheles*.
testacea, *Uranotaenia*.
testaceus, *Chrysops*.
Tetracnoides rugosus, sp.n., in Ceylon, 281.
Tetracnoides semilunaris, sp.n., on *Cymbopogon* in Ceylon, 282.
Tetrastichus unni, a parasite of lac insects in India, 38.
texana, *Tachardiella* (see *T. mexicana*).
Theobaldia annulata, in the Dardanelles, 3.
Theobaldia longiarcolata, in the Dardanelles, 3.
Theobroma cacao (see *Cacao*).
Theresia ampelophaga, bionomics and control of, in vineyards in the Crimea, 393-397.
Theriopectes, a subgenus of *Tabanus*, 301; status of, 305.
Thielaviopsis paradoxa, infesting sugarcane in Br. Guiana, 251.
Thoesa, Tachinid parasite of, in Java, 117.
Thrips acaciae, on *Caesalpinia* in Uganda, 130.
Thrips kikuyensis, food-plants of, in Uganda, 129, 130.
Thyridomyia, 356.
Tiracola plagiatæ, Tachinid parasite of, in Malaya, 114.
Tirathaba trichogramma, Tachinid parasite of, in Malaya, 119.
titillans, *Lyperosia*.

trāgrādhi, *Pityophthorus*.

Trees, entomological analyses of, **169-174**.

Trichogramma minutum, parasite of *Diatraea* spp. in Br. Guiana, **259**; parasite of *Megastes grandalis* in Trinidad, **372**.

trichogramma, *Tirathaba*.

Tricholyga aberrans, hosts of, in Malaya, **121**.

Tricholyga sorbillans, **117**; hosts of, in Oriental region, **120**.

Triclista, **293**; not considered distinct from *Scaptia*, **299**.

Triclista limbivervis, identity of, **304**.

Triclista singularis, identity of, **304**.

trifoli, *Trionymus*.

trilineatus, *Aedes* (Finlaya).

trilobitoides, *Dialeurodes* (*Rhachisphora*).

Trinervitermes (see *Eutermes*).

Trinidad, new Coccid from, **52**; bionomics of *Megastes grandalis* in, **369-372**; thrips in, **132**.

trinidadensis, *Phenacoccus*.

Trionymus trifoli, internal anatomy of, **25-29**.

Trioxys brevicornis, parasite of *Myzus cerasi* in Britain, **93**.

Triphleps australis, sp. n., destroying eggs of *Heliothis obsoleta* in Queensland, **361**.

Triphleps insidiosus, destroying eggs of *Heliothis obsoleta* in U.S.A., **362**.

Triphleps puncticollis, **362**.

tritaeniorhynchus, *Culex*.

tshirichu, *Coccophagus*.

Turanochrysops, subgen. n., **326**; (see *Chrysops*).

Tylococcus (see *Farinococcus*).

typographus, *Ips*.

U

Uganda, new Coccids from, **52, 53, 57, 58, 61**; bionomics and control of *Stephanoderes hampei* in, **347-354**; thrips in, **125-142**.

ugandae, *Pseudococcus*.

umbrinus, *Tabanus*.

ungulata, *Lepidosaphes*.

unidentatus, *Calotermes militaris*.

uniformis, *Culex*.

Uranotaenia campestris, factors in ecology of, **190**; oxygen requirements of, **196**; breeding-places of, **205**; feeding habits of lava of, **227**; alkalinity of gut of, **229**.

Uranotaenia kalabahensis, sp. n., in Sunda Islands, **43**.

Uranotaenia papua, male of, described from Moluccas, **44**.

Uranotaenia testacea, **44**.

urichi, *Liothrips*.

usambaranus, *Psocus nebulosus*.

uzeli, *Gynaikothrips*.

V

vagus, *Anopheles*.

Vanessa polychloros, influence of temperature on development of, **364**.

varians, *Anthonomus*.

variegatus, *Aedes*.

veitchi, *Pseudocacilius*.

Veprius, not an Australian genus, **304**.

Veronica, *Myzus caesi* not found on, in Britain, **91**.

vicina, *Hemimaschera*, *Scaptia*.

Vine, Grape, *Theresia ampelophaga* on, in the Crimea, **393-397**.

violacea, *Scaptia*.

vishnui, *Culex*.

vitiensis, *Psocus* (*Amphigerontia*).

vittaticollis, *Mecostylus* (*Dialictus*).

Volvox, association of, with mosquito larvae in Ceylon, **226**.

vorax, *Protostrophus*.

W

wainwrighti, *Coenoprosopon*.

walkeri, *Palimmecomyia*.

Wax Scale, Florida (see *Ceroplastes floridensis*).

whitmorei, *Culex*.

Winthemia quadripustulata, **116**.

Winthemia semiberbis, sp. n., hosts of, in Malaya, **115**.

wistariae, *Pseudococcus*.

woglumi, *Aleurocanthus*.

X

Xanthogramma pfeifferi, predacious on *Helopeltis* in Nigeria, **322**.

xenotermis, *Odontotermes*.

Xiphosoma azteca, parasite of *Megastes grandalis* in Trinidad, **372**.

Y

ypsilon, *Agrotis*.

Z

Zaphanera cyanotis, gen. et sp. n., on *Cyanotis* in Ceylon, **282**.

zeylanica, *Dixa*.

zeylanicus, *Aleurolobus*.

Zizyphus jujuba, lac insects on, in India, **30**.

Zygobothria, **115**.

INDEX TO NAMES OF PERSONS.

- Aarstad, K. A., 43.
 Adler, S., 399.
 Aldrich, J. M., 120.
 Arris, K., 328.
 Atkins, W. R. G., 188, 189, 198, 200,
 203 note, 207, 228, 229, 233, 245.
 Austen, E. E., 1, 15, 97, 114, 293, 295,
 307, 399.
 Autran, E., 40.
 Ayyar, Subramania, 241.

 Bagnall, R. S., 133, 136.
 Baker, C. F., 114, 120.
 Balfour, A., 45, 196.
 Ball, N. G., 188, 224.
 Ballard, E., 183, 329, 361, 362.
 Barber, T. C., 250.
 Barraud, P. J., 3, 206, 210 note, 218,
 377.
 Bate, Miss D. M. A., 8, 22.
 Beeson, C. F. C., 377, 378.
 Bennett, W. H., 8.
 Bequaert, J., 293.
 Berlese, A., 28, 364.
 Bernard, C., 323.
 Bezzi, M., 22, 113.
 Blood, B. N., 311.
 Bodkin, G. F., 143, 249, 259.
 Bowen, W. W., 176.
 Box, H. E., 72, 249.
 Boyd, M. F., 308.
 Brain, L. Lewton, 115.
 Brandt, 229.
 Brèthes, J., 293, 298.
 Broquet, C., 121.
 Brug, S. L., 44.
 Buchner, P., 28.
 Burkill, J. H., 35.
 Burrows, C. R. N., 377.
 Buxton, P. A., 23, 151, 188, 399.

 Calman, 206.
 Carl, 160.
 Carter, H. R., 151, 207.
 Chamberlin, J. C., 31 and note.
 Chidester, 218.
 China, W. E., 361.
 Clark, 189, 228.
 Cleare, Jr., L. D., 249, 252, 253, 255
 note, 256, 257, 259, 263, 264.

 Cockerell, T. D. A., 32, 33, 40.
 Collin, J. E., 95, 97.
 Collins, C. W., 178.
 Coquillett, D. W., 293, 294, 298.
 Corbett, G. H., 114-122, 267.
 Corson, J. F., 355, 356.
 Cotterell, G. S., 77.
 Cowland, J. W., 369.
 Cragg, F. W., 198, 228.
 Crawley, W. C., 259.
 Cross, H. E., 23.
 Cuthbert, B., 344.

 Dammerman, 178.
 Darling, S. T., 45.
 Desneux, 379, 380, 382.
 de Vogel, W. T., 45, 196.
 Dietz, H. F., 32.
 Dobrovliansky, V. V., 85, 91.
 Dodd, A. P., 330.
 Dogiel, 234.
 Dominguez, 40.
 Doubleday, E., 8.
 Dutt, G. R., 155.
 Dutton, J. F., 45.

 Ebner, 137.
 Edwards, F. W., 3 note, 188, 218.
 Ellis, 232, 233.
 Emel'yanov, A., 325.
 Enderlein, G., 285, 293, 294, 299, 300,
 301, 303, 304, 305, 306.
 Ernst, 178.
 Escherich, K., 379, 380, 386, 392.

 Farrell, D. J., 301.
 Fedorov, S. M., 393.
 Felt, E. P., 181.
 Ferguson, E. W., 293, 306.
 Ferris, G. F., 163, 375.
 Fiske, W. F., 219, 235.
 Flatterly, 206.
 Fletcher, T. B., 155 note, 177, 280.
 Foley, F. H., 45.
 Fraser, A. D., 1, 3, 4, 5, 8, 9, 16, 28.
 French, C., 85.
 Fritsch, 188, 219, 224, 230, 231, 232.
 Fry, 207.

Gahan, A. B., 373.
Garman, H., 361.
Gater, B. A. R., 114, 115, 117-122.
Gillette, C. P., 85, 91.
Girault, A. A., 183, 345 and note.
Golding, F. D., 142, 319, 322.
Gough, L. W., 145.
Gowdey, C. C., 125, 347, 353.
Green, E. E., 32, 35, 36, 41, 51, 54,
155 note, 230, 233, 267-279, 281-
284, 381.
Greene, C. T., 113, 116.
Greenwood, W., 126, 130, 137, 140,
290.
Griffitts, T. H. D., 45.
Gugnion, 379.

Hacker, A., 187, 199, 200, 201, 202,
208, 211, 242, 246.
Haga, J., 43.
Hargreaves, E., 125, 126.
Hargreaves, H., 53, 54, 57, 58, 61, 125,
126, 128, 129, 130, 132, 135, 137,
141, 142, 347.
Harris, G. T., 189, 198, 203 note, 245.
Harrison, 241.
Harrison, Sir J., 257, 264.
Henry, M., 306.
Hill, G. F., 55, 306.
Hoke, Miss, 165.
Holdaway, F. G., 329, 345 note.
Hollande, 365, 366.
Holloway, T. E., 252, 253.
Hood, J. D., 125, 128, 130.
Hopkins, G. H. E., 151.
Hough, W. S., 25.
Howard, C. W., 70, 121.
Howlett, F. M., 212.
Hutson, T. C., 116, 121, 379.
Hyatt, P., 375.

Iyengar, M. O. T., 187.

Jack, R. W., 104.
Jacobson, 178.
James, S. P., 188.
Jameson, A. P., 121, 228, 229.
Jaynes, H. A., 121.
Jepson, F. P., 139.
Jewett, H. H., 361.
Johnston, H. B., 175, 311, 313.
Johnstone, 229.
Jordan, D. Starr, 41.

Karny, H. H., 125, 285.
Keilin, D. E., 229.
Kemner, N. A., 379.
Kimmins, D. E., 97.

King, H. H., 175, 359.
Kligler, I. J., 45.
Koebele, A., 375.
Kowalski, J., 81.
Kozhanchikov, D., 326.
Krüber, O., 6 and note, 9, 13, 326.

Ladell, W. R. S., 160.
Laing, F., 51, 267.
Lamborn, W. A., 187, 198, 199, 202,
204, 207, 208, 211, 215, 217, 219,
225, 226, 229, 242, 243.
Lean, O. B., 58, 319.
Lebour, M. V., 200.
Leeffmans, S., 120, 349 and note.
Lefroy, H. M., 155 note, 157, 249.
Lewton Brain, L., 115.
Loftin, U. C., 252, 253.

Macfie, J. W. S., 355.
MacGillivray, 61, 164, 166.
MacGregor, M. E., 48, 188, 192, 212,
229, 242, 315.
MacLendon, 233.
Mahdihassan, S., 31 and note, 32, 37,
38, 41.
Marlatt, C. L., 275.
Marshall, G. A. K., 51, 62, 65, 67, 113,
125, 132, 285, 289, 379.
Martin, W. M. J., 1, 5, 6, 8, 9.
Maulik, S., 77.
Mayné, R., 125, 142.
Menzel, R., 116, 117, 121, 323.
Mereshkovsky, S., 365, 366.
Moore, H. W. B., 249, 259, 263.
Moreau, 365, 366.
Morrill, A. W., 146.
Morrison, H., 32, 40.
Myers, L. Emery, 164.

Neave, S. A., 125, 130.
Newstead, R., 399, 401.
Nicholls, L., 224, 230.
Nietner, 379, 389.

Oldenberg, L., 121.

Paillot, A., 366.
Patterson, W. H., 77, 321.
Patton, W. S., 198, 228, 307.
Petch, T., 188, 230, 379.
Pierantoni, U., 28.
Pleske, F. D., 325, 326.
Pole, J., 283.
Pospelov, V. P., 363.
Priesner, H., 125.
Prout, L. B., 377.

Quaintance, A. L., 278.
 Quelch, J. J., 249, 256.

Ramachandra Rao, Y., 74.
 Ramakrishna, T. V., 74.
 Ransome, J. E. G., 99.
 Ricardo, Miss, 8, 16, 299, 300, 303, 306.
 Rich, Miss, 188, 220.
 Ritchie, A. H., 56, 64, 66, 126, 130, 198.
 Rodenwaldt, E., 44.
 Rosenfeld, A. H., 250.
 Ross, Sir R., 187, 188.
 Ross, W. A., 85, 91, 92.
 Roubaud, E., 230, 234, 364.
 Rudolfs, W., 243.
 Rutherford, A., 268, 269, 271, 279.

Sasaki, 114.
 Saunders, L. G., 60, 356.
 Schimper, 225.
 Schischkoff, 8, 9, 16.
 Senior-White, R., 187, 197, 201, 207, 209.
 Shelford, 201.
 Shinji, G. C., 29.
 Shrader, F., 28.
 Sidky, M., 23.
 Silvestri, F., 31.
 Simmonds, H. W., 51, 54, 59, 288.
 Sinton, J. A., 399.
 Sjöstedt, Y., 161.
 Sørensen, 187, 188, 217.
 Stackelberg, A., 325.
 Strickland, C., 187.
 Subramania Ayyar, 241.
 Summers, J. N., 117.
 Surcouf, Baron J. M. R., 16, 17.
 Swynnerton, C. F. M., 99.
 Szilády, Z., 6 and note, 16, 325, 326.

Taylor, 301.
 Theobald, F. V., 44, 85.

Theodor, O., 45, 399.
 Thomasset, H. P., 135.
 Townsend, C. H. T., 121, 259.
 Trägårdh, I., 169.
 Trybom, 126, 130, 135, 136, 137.
 Turnbull, A. M. D., 103.
 Turner, R. E., 259.

Urich, F. W., 132, 369, 372.
 Uvarov, B. P., 159, 363.

Veitch, R., 285, 286, 289, 290.
 Villeneuve, J., 113, 114, 121.
 Vogel, W. T. de, 45, 196.

Walton, 206.
 Wasmann, E., 379, 386, 388.
 Waterston, J., 82, 309, 373.
 Watson, M., 188, 201, 223, 240, 241, 244.
 Weinberg, I., 143.
 Wenyon, C. M., 8, 8, 16.
 Wesenburg-Lund, C., 187, 198, 200, 212, 218, 219, 220, 227, 230.
 West, 219, 224.
 White, G. F., 366.
 Whitfield, F. G. S., 95.
 Wilkinson, D. S., 75.
 Williams, F. X., 261.
 Williamson, K. B., 229, 233.
 Wilson, H. F., 91.
 Wimshurst, F. M., 85.
 Winkler, 189.
 Withycombe, C. L., 52, 337 note.
 Woglum, R. S., 267, 269, 271, 274, 279.
 Wolcott, G. N., 257, 259, 264.

Young, C. G., 258 note.
 Yvernault, A., 45.

DATES OF PUBLICATION IN PARTS.

Part I	pp. 1-112	... 13 July 1925.
Part II	pp. 113-186	... 24 October 1925.
Part III	pp. 187-292	... 9 January 1926.
Part IV	pp. 293-408	... 30 March 1926.

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